BIOLOGY 104

MARINE BIOLOGY

LABORATORY MANUAL

THIRD EDITION

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Marine Biology
Laboratory Manual

Third Edition

Biology 104

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Resolution is limited by the wavelength of light used and in this case, blue light is used to resolve objects separated by 200 nm (0.0002 mm). Even with the 40x objective in place, your microscope will still have high quality resolution.

Examine the slide of the colored threads with the dissecting microscope. Notice how much greater the depth of focus is, and that you have a stereoscopic view of the threads.

Part 2. Making Wet Mounts

Wet mounts are an excellent way to view live materials under the microscope. To make a wet mount, take a clean, dry microscope slide and add a drop or a half-drop of material from the specimen jar. Remove a coverslip from the box and place the edge on the slide so it touches the edge of the liquid. Slowly lower the coverslip according to Figure 1-1.

Lowering it in this manner will help you avoid forming and trapping air bubbles. Twist a tissue to wick away excess liquid, and then view the slide under the compound microscope. Note that you will not be using dyes or stains in this lab.

Larger organisms that we will be observing later in the term such as brown planaria or algaes should be mounted on depression slides and viewed on the dissecting microscope.

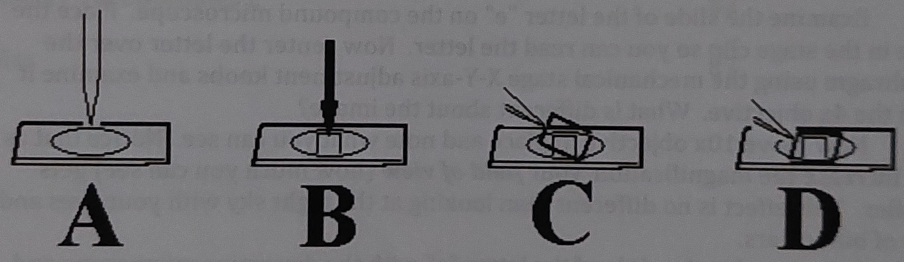

Figure 1-1. The proper technique to use when making a wet mount. A add a drop of water; B place specimen on slide; C place coverslip on slide so the edge touches the liquid; D slowly lower coverslip and then wick away excess fluid.

Part 3. Prokaryotes

Eubacteria

Prokaryotes are largely single-celled organisms that can occur singly or in colonies. They lack internal membrane bound organelles such as a nucleus or mitochondria. All contain cell walls and reproduce by binary fission. Many prokaryotes are primary producers (***autotrophs***) with the vast majority of these getting their energy via ***photosynthesis***. Prokaryotes are an important part of food webs often serving as a food source for other organisms as well as being key in nutrient cycling. As primary producers, they form the basis of food webs and the marine environment is no exception.

All of these organisms are small so use the 4x objective to first get the general focus. Typically, this involves focusing on something known such as along the edge of the coverslip. Then increase magnification to the 10x objective lens and scan along the edges of the coverslip - look for motion (on wet mounts) or clumps of material. Once you have found something that looks interesting increase magnification to the 40x objective (**remember to only use the fine focus with the 40x objective**). If you want to scan different areas of the slide, return to the 10x objective and repeat the process.

Cyanobacteria (Blue green bacteria)

Blue-green bacteria used to be called blue-green algae due to bacteria historically being classified as plants and later because cyanobacteria were still classified as algae. Like other prokaryotes, cyanobacteria lack internal membrane-bound organelles such as nuclei or chloroplasts. In place of chloroplasts, they have photosynthetic membranes to utilize energy from the sun. Today you will examine prepared slides and several cultures of cyanobacteria and will contrast these with cultures of single-celled, photosynthetic ***eukaryotes***.

Examine a prepared slide of *Oscillatoria*. *Oscillatoria* is found locally in pools of salt marshes where they form dense mats. Note the lack of any internal structure in the cells. See page 129, Fig. 6-8b in your book- identify the ***heterocysts*** and know their function (***nitrogen fixation***). Make a wet mount of *Oscillatoria* and view it under the microscope.

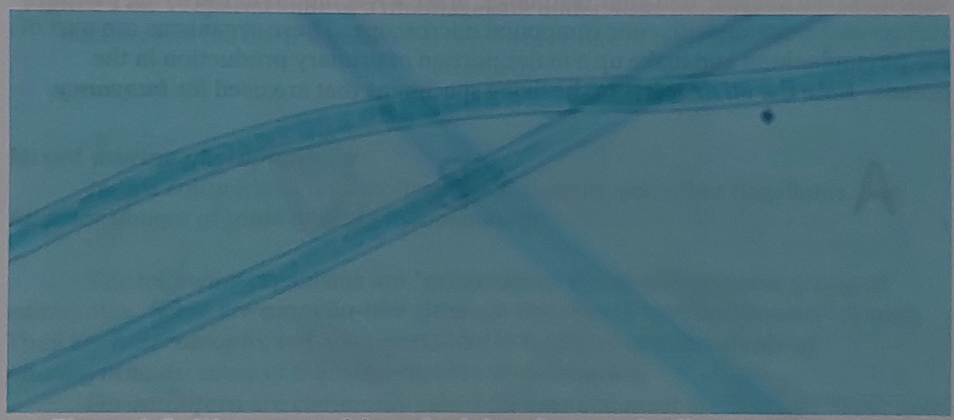

Figure 1-2. Wet mount of the ***colonial prokaryote*** *Oscillatoria* under 1000x magnification. The cell walls clearly visible.

Examine a prepared slide of *Spirulina*. Make a wet mount from the culture of *Spirulina* (See Atlas), which is sold as health food for reasons that remain unclear. Examine the culture of "pond scum" which is a mixture of various types of microorganisms, some photosynthetic.

Part 4. Eukaryotes

Eukaryotes are all the other life forms on earth. Eukaryotes have a membrane-bound nucleus and contain membrane-bound organelles. Single-celled eukaryotes were formerly grouped together in a Kingdom known as Protista; as this group is now considered ***polyphyletic*** it is no longer a valid taxon.

Diatoms and ***dinoflagellates*** are also known as ***unicellular algae*** because they are single-celled and capable of photosynthesis, *i.e.* they are ***photoautotrophs***. These organisms also make up the bulk of ***phytoplankton***.

Flagellates are a group of organisms placed within Stramenopiles (organisms with two flagella) along with diatoms (cartoon of one on page 139 of your textbook). These organisms are also photoautotrophs.

Examine the slides of ***Euglena***. It is unlikely you will be able to see the flagella on these preserved slides. Note that these organisms are considered part of the phytoplankton.

Make a wet mount of Euglena, if it is available.

Diatoms

Diatoms are single-celled organisms that have both planktonic and benthic species. The shape, pores, knobs, and grooves on their ***frustules*** are used to classify these organisms. Diatoms range in size from 10 μm to 1 mm.

Examine prepared slides of "whole cells" and the "diatom strew" slides of the frustules (see Chapter 6 in your textbook). Make a wet mount of the living diatom culture and examine with your compound microscope. These organisms are part of the phytoplankton and make up a major portion of primary production in the oceans. Note the ***oil droplets*** in the living specimens that are used for ***buoyancy***.

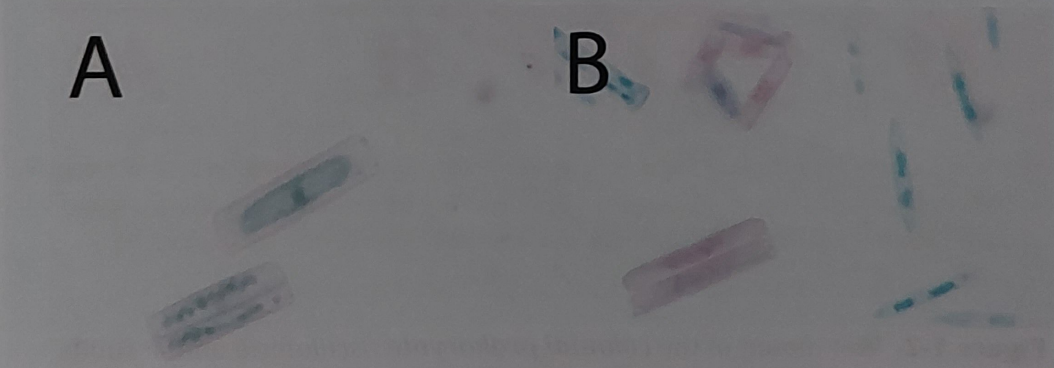

Figure 1-3. Prepared slides of marine diatoms under 400x magnification.

Dinoflagellates

Dinoflagellates are single-celled organisms with two flagella in grooves on their cell surface. The number, size, and shape of their cellulose plates are used to identify different species.

Examine the prepared slides and make a wet mount of the live culture. These

organisms are part of the phytoplankton and are responsible for ***red tides***. Note the ***test*** and the ***flagellum***. Not only are these organisms capable of ***photosynthesis***, but they can also ingest food via ***phagocytosis***! The living dinoflagellates move with a spiral motion; on some that are stationary you may be able to see the groove that one of the flagella fits in to. You may also see some living flagellates swimming around (they were placed in the culture for food).

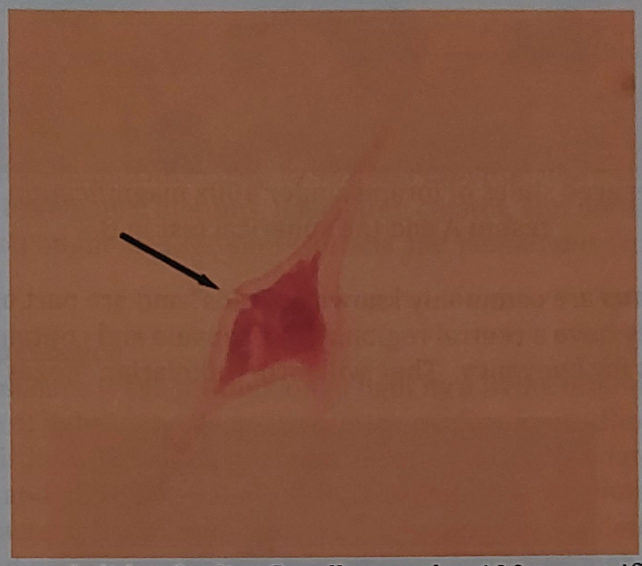

Figure 1-4. Prepared slide of a dinoflagellate under 400x magnification. Note the nucleus and the central groove (arrow) where one of their flagella would be attached.

Mixed marine *phytoplankton*

In this culture look for dinoflagellates, diatoms, and other flagellates. See Atlas for images of some typical phytoplankton.

The following organisms are "protozoans," which are a diverse group of eukaryotes. Some are ***amoeba-like*** although they live in various "houses" or tests. They are ***heterotrophs*** and are animal-like in that they ***are incapable of photosynthesis;*** some of them are capable of locomotion.

Foraminifera are commonly called ***forams*** and most are benthic. Make note of the ***test*** ("shell"), which may be multi-chambered. Planktonic forams have spherically symmetrical tests while benthic forams have tests in rows or spirals. Forams are part of the ***zooplankton***. The tests of dead forams form important marine sediments and are a source of chalk.

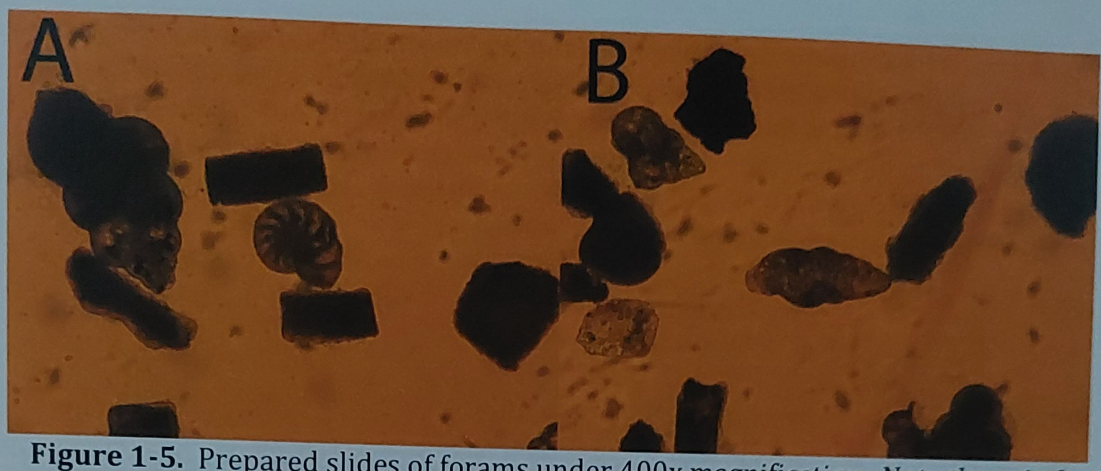

Figure 1-5. Prepared slides of forams under 400x magnification. Note the spiral test in A and the spherical test in B.

Radiolarians are commonly known as "rads" and are part of the zooplankton. They have a central region with a capsule and contain oils and other low-density fluids for buoyancy. They will form radiolarian "oozes" over time at great depths.

Figure 1-6. Prepared slide of typical radiolarians under 200x magnification.

Heliozoans are the most abundant planktonic "protists" with very few of them being pelagic. Examine the slide of *Actinosphaerium*. The pores in the surface are where the cytoplasm would extend to enable them to move through their environment.

Ciliates

Ciliates are protozoans that have ***cilia*** used for locomotion and feeding.

Vorticella is a ***stalked ciliate***. These organisms are often found attached to the base of kelp and we may see some when we examine kelp in a future lab. *Vorticella* live attached to some type of hard substrate via their stalk. Note that the "stalk" is contractile. They use their ***cilia*** to strain plankton from the water. This type of feeding is known as ***filter feeding***. Examine the prepared slides and the live specimens, if available.

Paramecium are ***free living benthic ciliates***. Examine prepared slides. Note the ***food groove*** used to ingest food. See Fig. 6-26 C on page 148 of your textbook. Make a wet mount of the live Paramecium.

Mixed protozoa

In this culture are live ciliates and flagellates. The easiest way to find them is to look in clumps of ***detritus***, which is ***dead organic matter***.

Marine benthic microorganisms

Make a wet mount of the sandy mud from Back Cove. Examine under the 4x and 10x objective lenses with your compound microscope. When you detect motion in the clumps of detritus go up to 40x and examine more closely. You should see the following organisms: diatoms, flagellates, ciliates, and perhaps cyanobacteria. You might also see some forams and nematodes (round worms).

Part 5. Bioluminescence

Bioluminescence is the production of light by a living organism. It is an important source of light in the deep-sea marine environment. Bioluminescent organisms use this light for communication, prey detection, predator avoidance, attracting mates, and illumination. Many microorganisms are bioluminescent including some bacteria and dinoflagellates. They can often be detected while scuba diving at night and moving your hand or an object rapidly through the water.

Questions

1. Which objective lens on the compound microscope do you never use the coarse focus with?

2. Which objective on the compound microscope should be in place when you put a new slide in the stage clip?

3. What is the difference between field of view and depth of focus?

4. How do magnification and resolution differ from each other?

5. What are some differences between prokaryotic and eukaryotic cells?

6. While working with a slide with a coverslip, on what structure will you focus first?

7. How does unicellular algae differ from blue-green bacteria?

8. What are some differences between dissecting and compound microscopes?

9. Contrast the diatoms and dinoflagellates that you examined.

10. What are some differences between ciliates such as *Paramecium* and dinoflagellates?

Laboratory 2: Algae

Part 1. Introduction

Marine macroalgae, commonly called "seaweeds," are photosynthetic, multicellular organisms that exhibit cellular differentiation; *i.e.* the cells are not all the same. However, they are considered less complex than the true (or vascular) plants. It is relatively easy to recognize which phylum (or division) seaweeds belong to because they are characterized by the photosynthetic pigments the algae possess. These pigments give seaweeds their distinctive color. We will examine prepared slides and whole specimens of green, brown, and red algae obtained locally. While the algae are relatively easy to place within each of the preceding groups, their life cycles are very complicated (see Chapter 7 of your text for more details).

Seaweeds are an important part of the marine environment because they serve as refuge for other plants and animals, provide substratum for barnacles, diatoms, and other organisms, and provide food for grazers such as marine gastropods. Benthic seaweeds are found attached to the substrata of the inner sublittoral region. Some limiting factors for the growth and distribution of seaweeds are light (both quality and intensity), tidal exposure, ice damage, wave action, current scouring, temperature, salinity, drying, mineral nutrients, competition, and herbivory.

There are several "parts" of a seaweed that you will need to know for this class. The ***holdfast*** secures the benthic species to the substrate. The ***thallus*** is the body of the seaweed and every cell (with few exceptions) is photosynthetic. The ***stipe*** of the seaweed is the stem-like area between the holdfast and thallus (or blade if the body is mostly flattened). By contrast, vascular plants have ***roots***, ***stems***, and ***leaves***.

Part 2. *Green Algae* (Phylum Chlorophyta)

Green algae are a diverse group of microbes and multicellular organisms living in the plankton and on the benthos. They are all green because they contain chlorophylls a and b as their primary photosynthetic pigments.

Sea lettuce *(Ulva*) is an alga with a broad, flat thallus that is found locally in tide pools. Examine the whole mount and the section slides of sea lettuce. If there is a live specimen available, examine it under the dissecting microscope. Then snip off a small piece, place it on a slide with a drop of seawater, and examine under low power on your compound microscope.

Figure 2-1. Live sea lettuce in a tide pool at Kettle Cove, Maine. Note the flat thallus.

There is also a ***filamentous green alga*** with hollow, unbranching blades that is now considered the same genus as sea lettuce (*Ulva*) but a different species. You may also see this particular alga referred to as *Enteromorpha* until the literature catches up with the new classification system. Examine the dish under your dissecting scope and then snip off a piece and mount it on a slide as you did with the sea lettuce.

Figure 2-2. Live filamentous green alga (*Ulva*) growing on a rock in a tide pool at Kettle Cove, Maine.

Chaetomorpha, also called green hair weed, is another filamentous green alga

found in tide pools. Snip off a small piece, place it on a slide with a drop of seawater, put on a coverslip, and examine under low power with your compound microscope. You should be able to see the individual cells in the filaments.

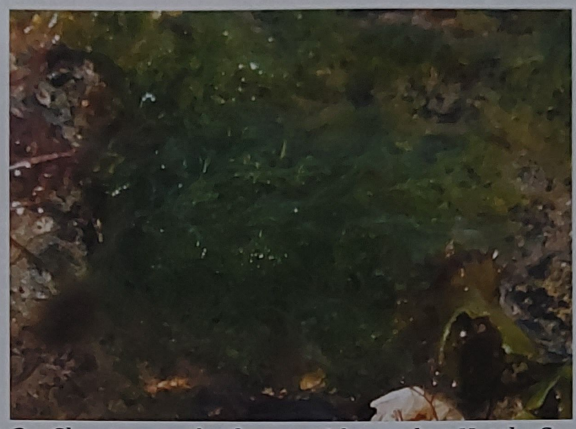

Figure 2-3. *Chaetomorpha* from a tide pool at Kettle Cove, Maine.

Part 3. *Brown algae* (Phylum Heterokontophyta/Phaeophyta)

Most brown algae are benthic and utilize chlorophylls a and c as their primary photosynthethic pigments. All appear olive green or brown due to an accessory photosynthetic pigment called fucoxanthin. Brown algae also form an important year round food source for herbivores. Many species of brown algae have ***air bladders*** for buoyancy.

Ascophyllum nodosum ***(knotted wrack)*** is a brown alga found in the ***high intertidal on rocks*** along the Maine coast.

Figure 2-4. Live Knotted wrack at Kettle Cove, Maine. Note air bladders and the external morphology of the organism.

Fucus sp. (***rockweed***) is a ***brown alga in the rocky intertidal***. There are several species of *Fucus* found along the Maine coast. Their distribution is often controlled by the amount of wave action in a particular locale, as you will see on the rocky intertidal field trip.

Figure 2-5. Live rockweed growing on the rocks at Kettle Cove, Maine. Note the air bladders and the external morphology.

Examine prepared slides showing male and female ***reproductive structures*** (known as conceptacles or receptacles; see figure 7-12, page 170 in your textbook). Examine the whole specimen and identify the stipe, holdfast, and ***receptacle***.

Figure 2-6. Part of a kelp washed in with the tide at Kettle Cove, Maine. Note the flat thallus.

Laminaria* (*kelp*)** is a ***brown alga found in the subtidal on rocks along the Maine coast. Examine the slides and note the general layout of the alga. Find the sporangia that give rise to spores, whose function is ***reproduction***. Examine the whole specimen and find the following: holdfast, stipe, and blade.

Figure 2-7. Dried holdfast of kelp on a shell. Note the "root-like" appearance.

Filamentous brown algae. If available, snip off a piece of this alga, place it in a depression slide with a drop of seawater and add a coverslip. Examine under low power and 10x with your compound microscope. You should see some colonial, stalked, golden brown algae (Chrysophytes) growing on the brown alga.

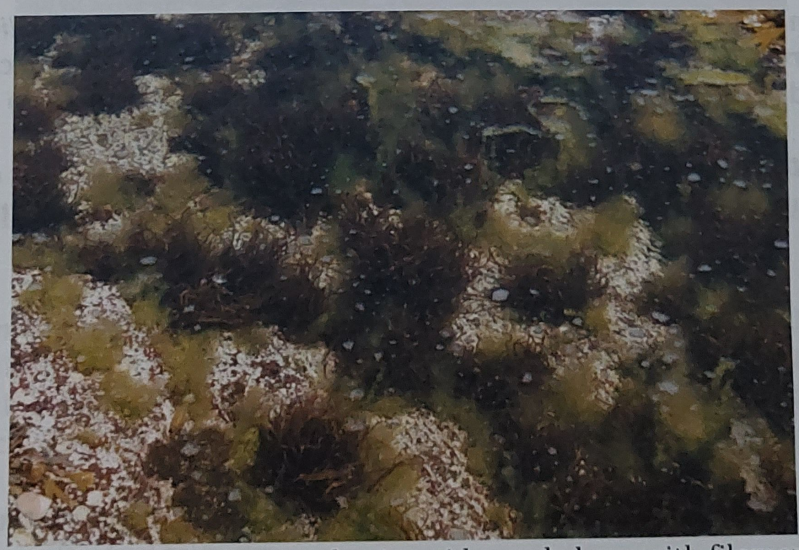

Figure 2-8. A filamentous brown alga in a tide pool along with filamentous green algae.

Part 4. ***Red algae*** (Phylum Rhodophyta)

These algae are deep red to pink and utilize chlorophylls a and d as their primary photosynthetic pigments. They get their color from the group of accessory photosynthetic pigments called phycobillins.

Most red algae are part of what is called the drift algal community. Many are also ***epiphytes*** and some have calcium carbonate in their cell walls.

Examine slides and whole specimen of the ***red algae*** *Polysiphonia*. Examine the prepared slides; then snip off a small piece, put it on a depression slide with a drop of seawater and a coverslip. Examine with both your compound and dissecting microscopes.

Figure 2-9. Filamentous red algae growing on knotted wrack.

Examine a slide and the whole specimen of the ***coral weed*** *Corallina*. This is a ***coralline red alga*** found in tide pools along the coast. They are often called coralline red algae since they have deposits of ***calcium carbonate***, as do corals.

Crustose red algae is a ***coralline red alga*** that secretes a matrix of ***calcium carbonate*** onto rocks and mollusc shells. It is found in tide pools along the Maine coast.

Figure 2-10. Coralline red alga near a bleached out specimen of the same species.

Figure 2-11. Tide pool with multiple species of algae visible. Note the crustose red in the upper middle portion of the image.

Ceramium rubrum is yet another branched red alga found along the coast. If available, snip off a small piece, place in a small dish of seawater, and examine under your dissecting scope. The small berry-like structures are for reproduction. Note the stalked ciliates and other organisms living on the colony.

Chrondrus crispus (Irish Moss) is an intertidal red alga is found in the lower intertidal zone attached to rocks.

Figure 2-12. An example of a filamentous red alga in a tide pool at Kettle Cove, Maine.

Mixed marine algae culture. Make a wet mount (use a depression slide) of the algae in the jar and examine under your compound microscope.

Part 5. ***Vascular plants*: *sea grasses, salt marsh grasses, and mangroves*.**

Examine the slides of the cross section of a leaf and root (see Fig. 7-15 on page 173 of the textbook). You should be able to identify these slides as coming from a ***vascular plant***. Examine any whole specimens that are available.

A. Seagrass

Eel grass is the only seagrass growing off the coast of Maine. It is photosynthetic, completely submerged, and is classified with lilies rather than terrestrial grasses. The flat leaves of eel grass have spaces that are filled with gasses to give buoyancy to the plant. Seagrasses are important in marine environments because they increase the stability of the substrate, reduce water turbidity, provide a food source to herbivores, and decaying blades contribute organic matter back to the ecosystem.

In subtropical and tropical ecosystems, they are used by sea turtles and as nursery areas for fishes. Many species of marine invertebrates also utilize this ecosystem for protection, feeding, and habitat.

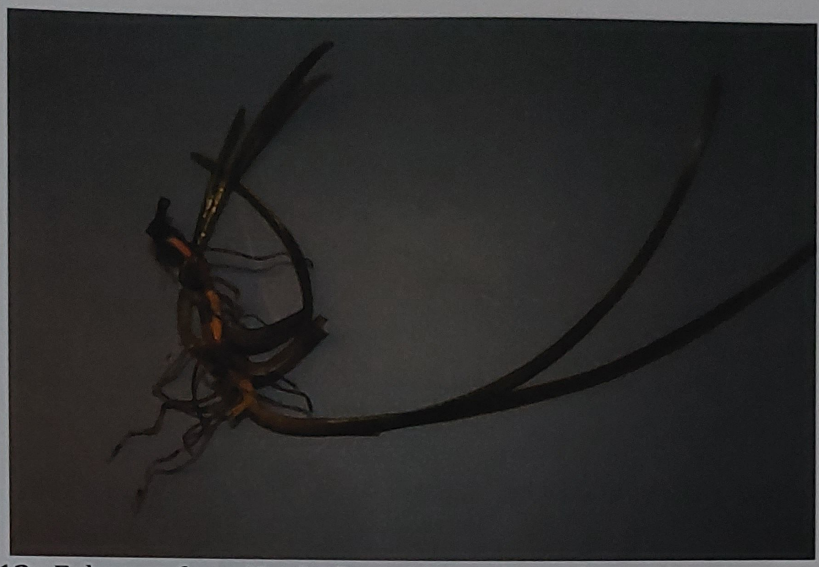

Figure 2-13. Eel grass from Kettle Cove, Maine. Note the roots, stems, and leaves of the plant.

B. Salt Marshes

Salt marshes are coastal ecosystems that are regularly flooded due to tides. Organisms that live here must be able to live under a wide range of environmental pressures including the amount of dissolved oxygen in the water and soil, temperature, and salinity. Algae, bacteria, invertebrates, birds, some terrestrial mammals, fishes, and plants make use of salt marshes in various ways.

There are several different plant species that you will see in lab or on the field trip to the salt marsh. There are two species of marsh grasses (*Spartina alterniflora* and *Spartina patens*) that are common where we go on the Spurwink marsh.

You should also recognize glasswort (*Salicornia* sp.), a ***succulent*** scattered throughout the marsh. Succulents are plants that have fleshy leaves with cells that fill with water to prevent dessication. *Salicornia* sp. have a purple or pinkish hue and are short plants.

You should also be familiar with the zonation of salt marshes.

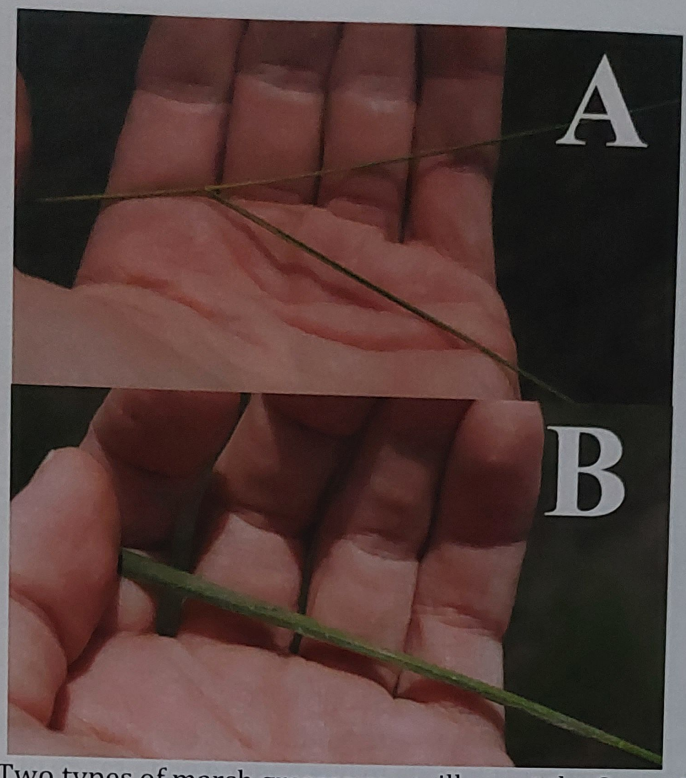

Figure 2-14. Two types of marsh grasses you will see at the Spurwink marsh. A. Saltmeadow cordgrass (*Spartina patens*). B. Smooth cordgrass (*Spartina alterniflora*).

Figure 2-15. Pan commonly found in salt marshes. These are depressions on the marsh that fill with water and sometimes dry out. There is a mat of blue-green bacteria on the upper edge of the pan surrounded by marsh grasses.

Figure 2-16. *Salicornia* growing amongst *Spartina* in a salt marsh.

Figure 2-17. Two species of *Spartina* growing in a salt marsh. Note the clear zonation between one species and another. This is due to a slight elevation change.

Figure 2-18. Community succession at Spurwink marsh. The tidal salt marsh is in the foreground and with distance from the salt water input and elevation changes there are changes in the ecosystem until a mature terrestrial forest emerges in the background.

C. Mangroves

Mangroves are ecosystems that are confined to the subtropics and tropics and include trees, shrubs, and the adjacent marine habitats. They occur in the intertidal and subtidal regions along shallow, protected humid coasts in soft substrata.

Mangrove communities serve many ecological roles. Their roots stabilize the substrate and reduce erosion. They also provide nesting or roosting sites for birds and produce substrate for epiphytic growth and provide a major contribution to food webs by the formation of detritus.

Mangrove communities are limited in part by the frequency and depth of tide and salinity peaks. Some mangrove trees have waxy leaves that secrete salt to prevent dessication.

Questions

1. What are some reasons that marine algae are important in the marine environment?

2. Describe some of the limiting factors for the distribution of seaweeds. Discuss the importance of these factors in Maine.

3. How are the parts of seaweeds different from the parts of marine flowering plants?

4. Compare and contrast the two filamentous green alga you examined in lab today.

5. Compare the mixed marine algae culture with the live specimen samples you made in lab today.

6. How are kelp, rockweed, and knotted wrack different structurally?

7. What were some differences in the types of green algae you examined today? Red algae? Brown algae?

Chapter 3: Sponges

Sponges are classified in the phylum ***Porifera*** and are the simplest animals. They lack symmetry, have no true tissues, and do not have any organ systems. They are at the ***cellular level of organization***. Sponges are sessile ***filter feeders*** that strain plankton and detritus (particulate organic material from decaying plants and animals) from seawater. ***Collar cells*** (choanocytes) move water through the sponge via their flagella (see Figure 8.2; page 191 from the textbook). A few species form symbiotic relationships with photosynthetic organisms; e.g. cyanobacteria.

Examine the slides of *Grantia* (=*Scypha*) and *Leucosolenia:* locate the ***cell types*** shown in your book (see Figure 8.2; page 191 from the textbook) (you should also know the ***function*** of each cell type). In addition, examine a slide of ***skeletal elements*** known as ***spicules,*** which are composed of calcium carbonate silicates.

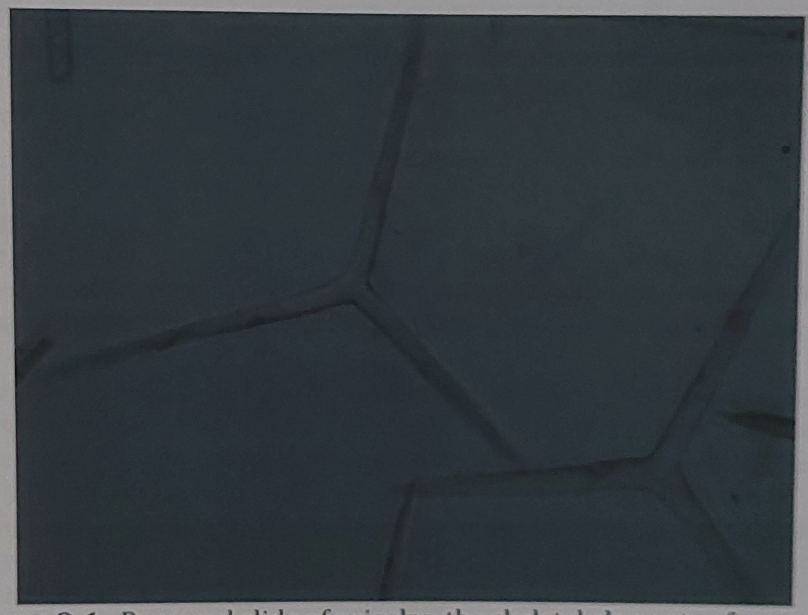

Figure 3-1. Prepared slide of spicules, the skeletal elements of sponges.

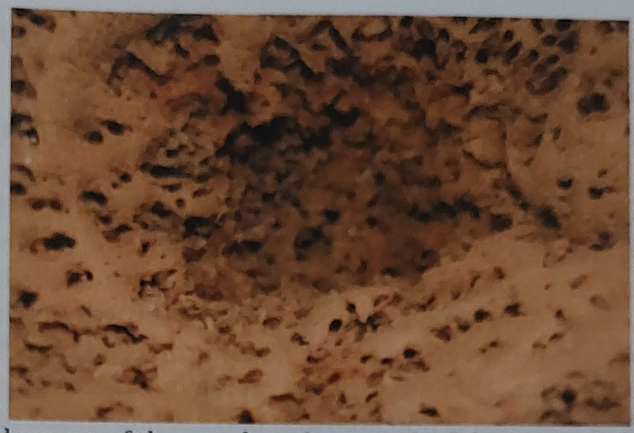

Figure 3-2. A close-up of the osculum (opening) of the sponge. Note the pores in the body of the sponge.

Examine the proteinaceous skeletal remains of these sponges. The protein fibers are known as spongin.

Look at (But don't touch!) the skeletal remains of a glass sponge. The fibers are made of silicate, i.e. glass. Some glass sponges form symbiotic relationships with shrimp.

Figure 3-3. Glass sponge. This particular sponge forms a symbiotic relationship with a mating pair of shrimp, which enter as juveniles and are sealed in by the sponge.

Questions

1. What were some of the differences in the sponges you examined in lab today?

2. What ecological roles do sponges play in the marine environment?

3. What were some of the morphological differences between the *Leucosolenia* and *Grantia* slides (not color changes)?

Laboratory 4: Cnidaria and Ctenophora

Part 1. ***Phylum Cnidaria***

Cnidarians are jellyfish and corals. You may see the term Coelenterata in older literature to describe, corals, true jellies, sea anemones, sea pens, and comb jellies (a different phylum called ***Ctenophora***). However, this classification is obsolete so we will refer to the current taxonomic organization. This phylum is considered at the ***tissue grade of organization;*** *i.e.* the animals have true tissues such as nerve and muscle. This phylum also exhibits ***radial*** symmetry with two distinct life forms (***medusa*** and ***polyp***; both are diploid) and the life cycles of many are complex. Both sexual and asexual reproduction is common in the phylum. See the text for information on the life cycles of these animals.

Cnidarians are important to numerous ecosystems and some species are part of the ***marine fouling community***. This miniature ecosystem gets its name because they typically foul docks, marinas, pilings, and boats. Larval as well as adult life stages of these organisms are part of the plankton and coral reef systems.

There are four classes within the phylum with examples of three of them in lab today.

Start by examining the prepared slide of the ***nematocysts*** of the polyp *Hydra*. Nematocysts are stinging structures found exclusively in Cnidaria. They are discharged from cells known as cnidae. If you have ever been stung by a jellyfish it was the nematocysts, which have hollow tubes full of poison, causing the sting. Nematocysts are used for ***prey capture*** (feeding) and ***defense*** against predators or other anemones. The pain and venom of stings can be mitigated with vinegar.

A. Class ***Hydrozoa***

This class contains both ***polyp*** and ***medusa*** forms. Hydrozoans are mostly colonial and generally small in size. Some form floating colonies; the most notable is the Portuguese man-of-war, which is not a jellyfish.

Examine the whole mount (w.m.), cross section (x.s.) and longitudinal section (l.s.) of the polyp Hydra. Note the general organization of the body (see Atlas).

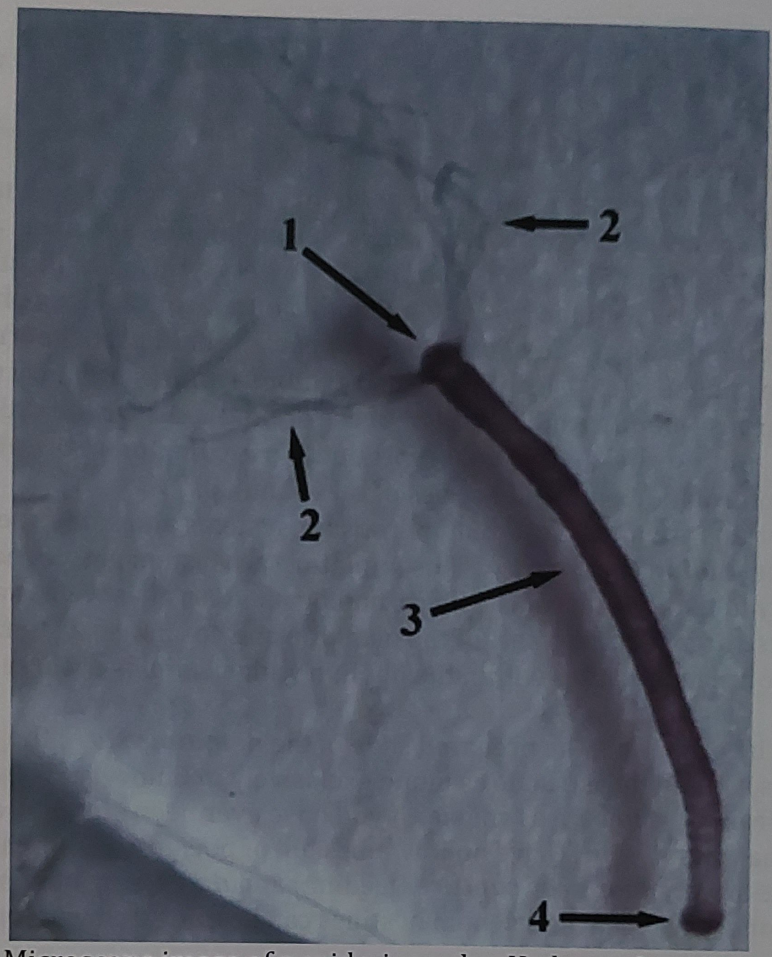

Figure 4-1. Microscope image of a cnidarian polyp Hydra under 40x magnification. Key: 1=Mouth; 2=Tentacles; 3=Body; 4=Pedal disc.

Examine the hydroid (with gonangia) and medusa of slides of *Obelia*. Be able to identify the parts listed here. Moreover, know the function, e.g. ***gastrozooid*** is for feeding, etc.

Figure 4-2. Microscope image of *Obelia* under 30x magnification with gastrozooid polyps and gonangia visible. Key: 1=Mouth; 2=Tentacles; 3=Gastrozooid; 4=Gonangia

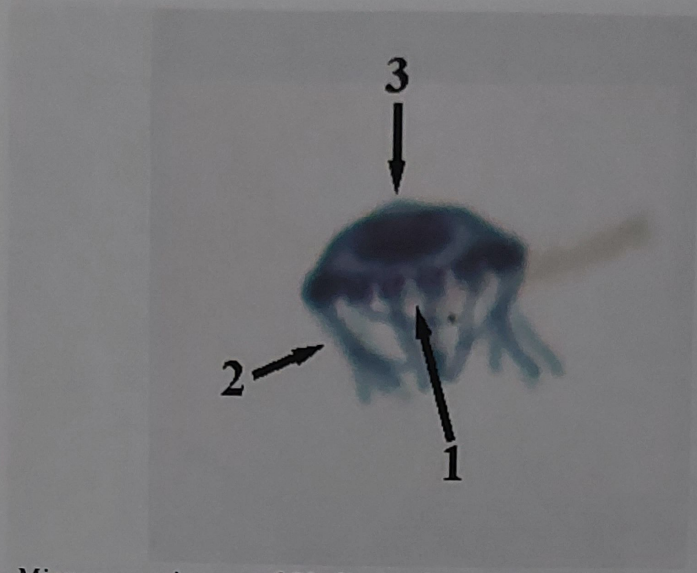

Figure 4-3. Microscope image of Obelia medusa under 100x magnification. *Key:* 1=Mouth; 2=Tentacles; 3=Body.

Examine the live specimen a local hydroid colony. Take a finger bowl back to your lab bench and examine with your dissecting microscope. The group of organisms living on the hydroid is a typical example of a marine fouling community. Look carefully and you will see various crustaceans, round worms, maybe some flatworms, and maybe sea slugs in the finger bowl. Snip off a piece of what looks like "grunge," place on a microscope slide with a coverslip, and examine with your compound microscope. You might see diatoms, stalked ciliates, green algae or other organisms. **Be sure and wipe off the stage of both the microscopes with a moist Kimwipe when you are finished.**

Next (if your instructor approves), snip off a polyp from a colony in the bowl on the side bench and place it on a depression slide and add a drop of 5% acetic acid in seawater, then place a coverslip over the polyp. Take the slide back to your work area and examine under your compound microscope. You should be able to see nematocysts discharging under the 40x objective.

Examine the preserved specimen of the Portugese Man O' War.

B. Class Scyphozoa

Scyphozoans are ***jellyfish***. In this class of organisms, the ***medusa*** form predominates; as a result, they are planktonic rather than benthic. If you have ever seen a large jellyfish it was in this class of organisms. Jellyfish are predators and can swim horizontally and vertically, albeit poorly. They use nematocysts in their tentacles to stun or paralyze prey and then use the tentacles to move the prey to their mouth. Jellyfish are fed on by sea turtles and some sea slugs.

Examine the life stages and medusa of the common jellyfish *Aurelia*. Identify

the structures and know their functions. Also know if life stage exhibits sexual or asexual reproduction (see the Atlas).

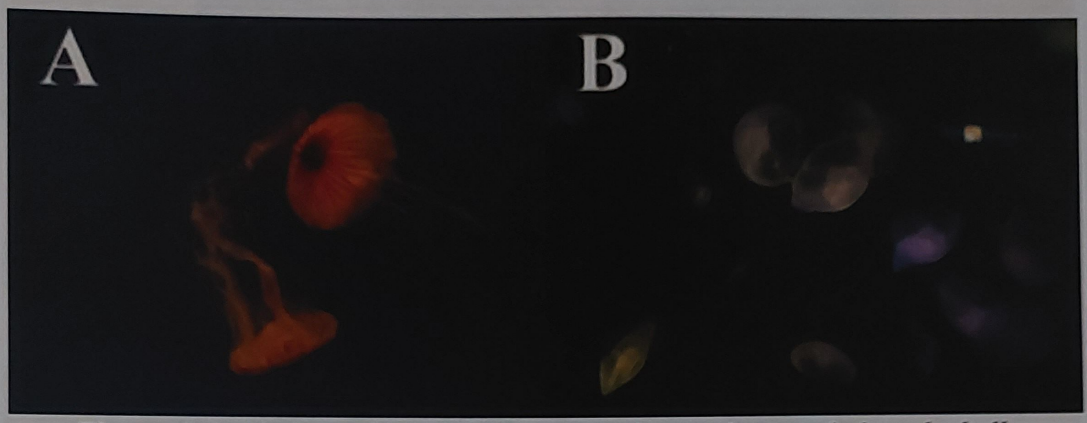

Figure 4-4. Medusa of jellyfish. The tentacles can be seen below the bell.

C. Class Anthozoa

Anthozoans are ***sea anemones, corals, and sea fans***. In this class the polyp form is the only life stage. Asexual reproduction seems to be the most common, or at least the most observed, form of reproduction in this class.

Examine the slide (x.s.; l.s.) of the sea anemone *Metridium*. ***Be able to identify the body, mouth, tentacles, pedal disc, and oral disc.***

Examine a live specimen of the local sea anemone *Metridium*. Take the specimen back to your work area and examine under your dissecting microscope. After you have identified the various anatomical structures, drop a **small** piece of mussel meat or frozen brine shrimp onto the oral disc of the anemone to observe feeding behavior (do this with the person sitting next to you in lab - you don't need the microscope to see feeding behavior).

Figure 4-5. Sea anemones covering a mussel. The tentacles and mouth are clearly visible on the anemone at the center of the photo. There is also some sea lettuce attached as well as skeleton shrimp, which we will cover in the chapter on arthropods.

Examine the skeletal remains of the sea fans, organ pipe coral, and stony coral. These animals are colonial and are all in the Class Anthozoa. Locate the depression where the coral polyp lived. ***You should know that these remains are from a Cnidarian.*** See Chapter 8 and 15 in your textbook and the Atlas for photographs of live corals!

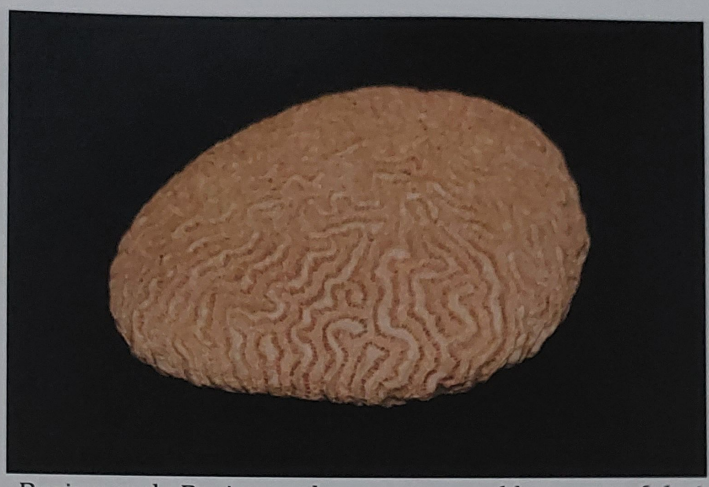

Figure 4-6. Brain coral. Brain corals are so named because of their superficial resemblance to the brain.

Figure 4-7. A typical branching coral. The depressions where the coral polyp lived is clearly visible.

Corals are very important organisms to the ecosystem. They are sessile animals that secrete calcium carbonate ($CaCO_3$), which forms the structure of these reef systems. Corals form symbiotic relationships with photosynthetic dinoflagellates, which gives the corals their color. The dinoflagellates also provide energy to the coral in exchange for a substrate for growth and protection. Corals are prey for various grazers and provide shelter for numerous fishes and invertebrates.

Sea fans and sea pens are examples of ***soft corals***. Sea pens (see Atlas) are fleshy organisms with the polyps specialized for specific functions. Sea pens can grow up to 2m in height. Examine the preserved sea pen under a dissecting microscope.

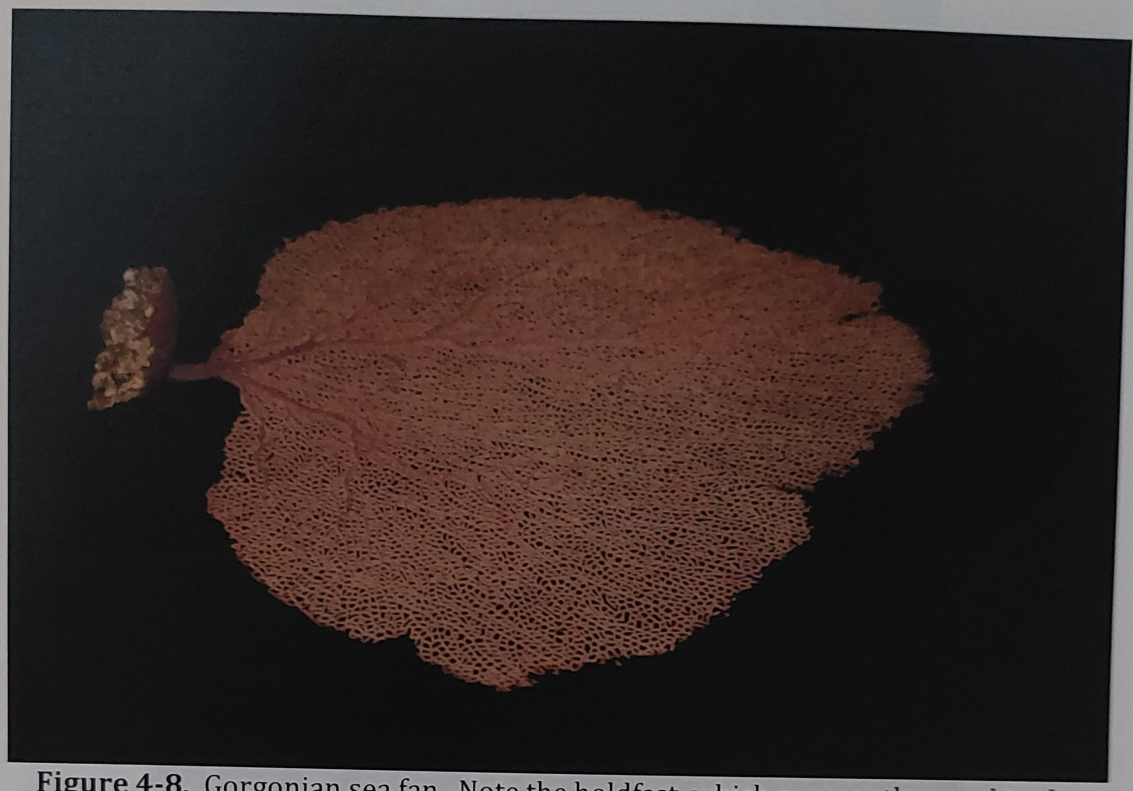

Figure 4-8. Gorgonian sea fan. Note the holdfast, which secures the coral to the substrate and the mesh-like network of the coral.

Sea fans (known as Gorgonians) form flattened, branching structures that resemble fans. Others may be bushy or whip-like in formation. Examine the sea fans.

Part 2. Phylum Ctenorphora (= *Comb Jellies*).

This phylum superficially resembles cnidarian medusae. They are ***radially symmetrical*** and are at the tissue or primitive organ level of development, but lack the nematocysts present in cnidarians. Comb Jellies often occur in "blooms" along the Maine coast in the summer. Ctenophores are part of the gelatinous zooplankton and are carnivores.

Be able to identify the following: ***mouth, comb (ctene) rows and know their function,e.g. feeding and locomotion.*** Nearly all ctenopores give off flashes of luminescence, which could be used for prey or mate attraction as well as predator deterrence.

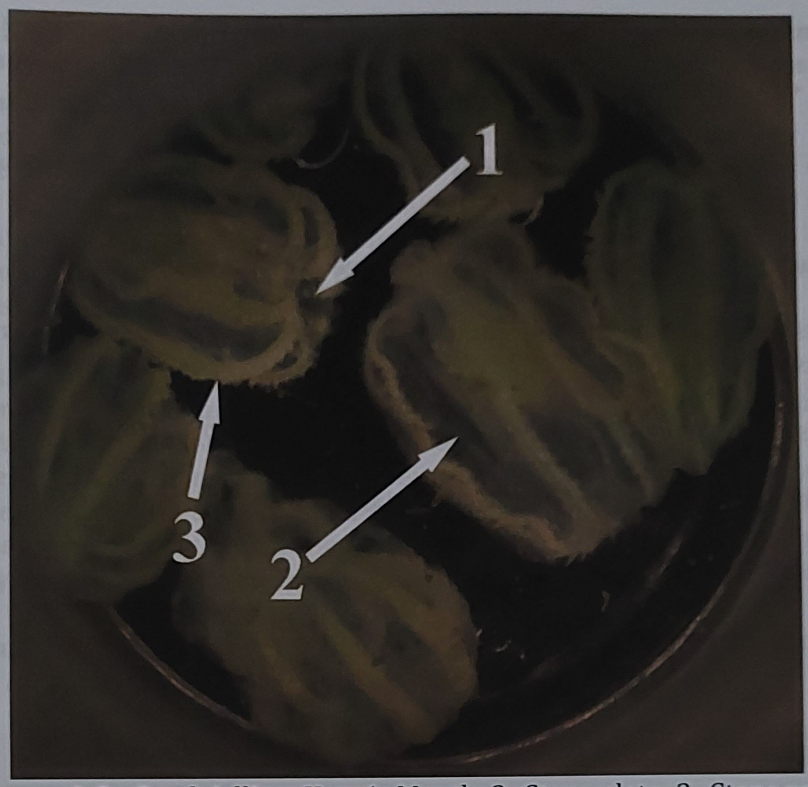

Figure 4-9. Comb jellies. Key: 1=Mouth; 2=Ctene plate; 3=Ctene row.

Questions

1. What are the life forms present in cnidarians (refer to the reading to understand the term "life forms")?

2. Which life form predominates each class of the cnidarian organisms you observed today?

3. Is radial symmetry present in every life stage of cnidarians?

4. Discuss the importance of the symbiotic relationships between corals and other organisms.

5. What is the importance of corals to marine ecosystems?

6. How are ctenophores different from cnidarians?

Laboratory 5: Marine Worms and Meiofauna

Part 1. Phylum Platyhelminthes *(=flatworms)*.

This is the first phylum that we have encountered that is ***bilaterally symmetrical***. These animals are at ***the organ level of development*** with a well-developed nervous system with a brain, a digestive system, and a complex reproductive system. Many are hermaphroditic. There are three classes in this large phylum with two of the classes being parasites in vertebrates, including humans, fish, whales, etc., and one being free-living.

A. Class Turbellaria: ***free living flatworms***.

Planaria are common in both saltwater and freshwater with some species found in the terrestrial environment. Planaria have been used increasingly in recent years as research organisms because of their remarkable ability to regenerate body parts and even whole organisms, provided there are enough cells left following lesion. They also are used in toxicology studies because their brain and simple nervous system allows for very specific behavioral responses to various substances.

Examine a slide of planaria. ***Identify the eyespots, gut (which is incomplete and lacks an anus), pharynx.***

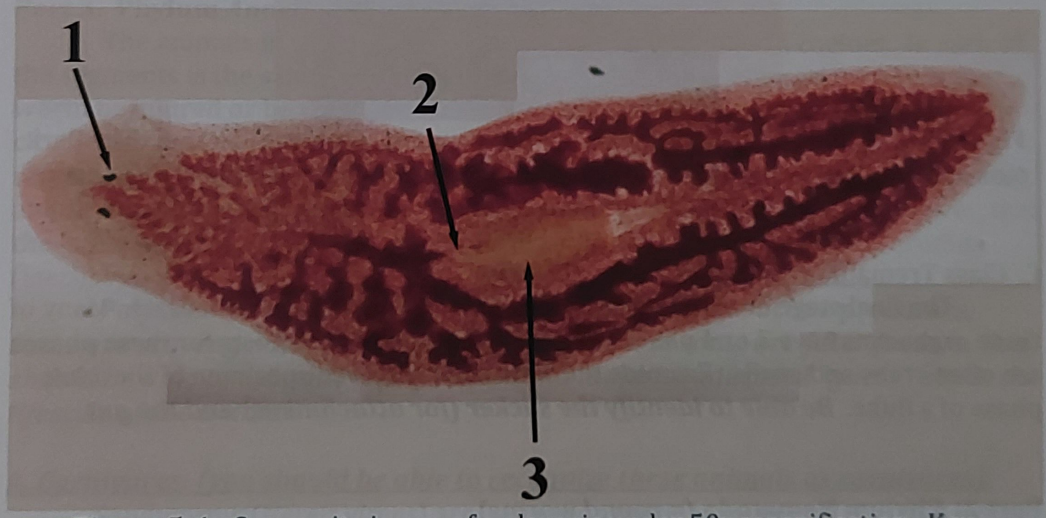

Figure 5-1. Composite image of a planaria under 50x magnification. Key: 1=eyespot; 2=pharynx; 3=gut.

Examine live planaria using a depression slide with some water from the jar of planaria. Examine either with the 4x objective of your compound microscope or with the dissecting scope.

Bdelloura is a marine flatworm that is oval shaped with a sucker for attachment to substrate or an organism. They often form symbiotic relationships

with horseshoe crabs, living on their gills and feeding on leftover meals of the crab.

Examine the slide of *Bdelloura*.

B. Class Cestoda: ***tapeworms***.

These organisms are intestinal parasites in vertebrates. Tapeworms grow by producing more segments (called proglottids), which are later released from the tapeworm's posterior end to leave the host in the feces. Examine the slides and preserved specimens. Be able to identify the following and know the function: ***scolex (attachment); segments (reproduction)***. Note that these animals ***do not have a gut***- they absorb nutrients across their body wall from the host's intestines.

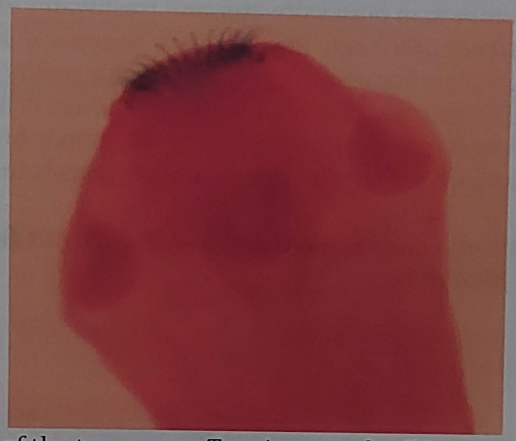

Figure 5-2. Scolex of the tapeworm *Taenia* sp. under 50x magnification. The dark pink spots on the scolex are the suckers and the dark lines at the top are the hooks.

C. Class Trematdoa: ***flukes***.

The final stage or adult phase of the life cycle resides in a vertebrate. Many of these organisms have 3 or 4 phases to their life cycles and the hosts for these phases are often crabs and snails. Examine the slide and preserved specimen of the adult phase of a fluke. ***Be able to identify the sucker (for attachment) and the gut.***

Part 2. Phylum Nematoda *(= round worms*).

Nematodes are one of the largest groups of animals on earth and they occupy almost every conceivable habitat. They are important benthic scavengers in marine ecosystems as well as intestinal parasites in vertebrates and play a critical role in nutrient cycling. They vary in size from microscopic to 5 cm. Roundworms have a thick, multi-layered epidermis called a cuticle.

Examine the whole mount of a round worm and be able to identify the ***gut***.

Examine the live specimens that are on the hydroid colonies. Put the finger

bowl under your dissecting scope- the nematodes are small, clear, and look like small snakes.

Figure 5-3. Composite image of a round worm (*Enterobius* sp.) under 50x magnification.

Part 3. Phylum *Annelida (=segmented worms*)

The animals in this phylum contain a body cavity called a coelom. In each of the segments is the same set of organs, which allows for regeneration should the worm be injured or be cut into pieces. They have a flow through gut as well as a circulatory system and many of them have appendages modified as gills for respiration. The majority of marine annelids are ***polychaetes (= Class polychaeta***), and these are the only examples we will examine in the lab. Be aware, however, that there are two other classes of annelids: Oligochaeta (earthworms) and Hirudina (leeches).

Polychaetes have many diverse lifestyles; some are active predators, some are scavengers, some are deposit feeders, and some are filter feeders. You should be able to examine a polychaete and make an educated "guess" about the lifestyle of the animal.

A. ***Carnivores: (you should be able to recognize these animals as carnivores).***

Sandworms (*Nereis virens*) are a common marine worm in Maine that lives in soft sediment. They possess ***parapodia*** with ***setae*** for support and locomotion.

Examine a preserved specimen of the *Nereis virens*. ***Identify the items listed in Figure 5-4.***

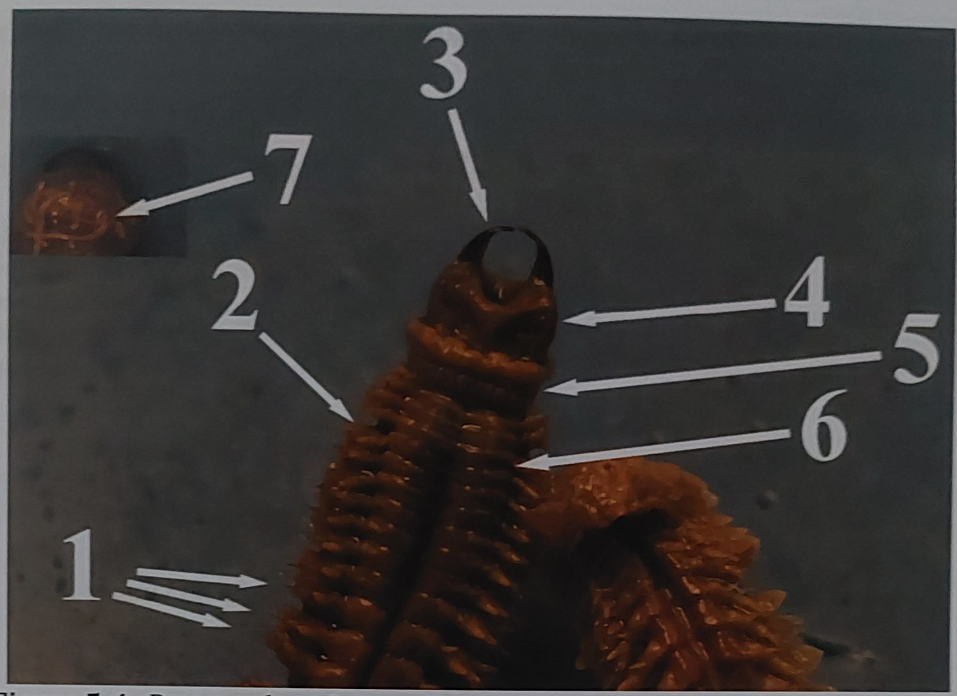

Figure 5-4. Preserved sandworm, *Nereis*. Key: 1=Setae; 2=Parapodia; 3=Jaw; 4= Head; 5=Peristomium; 6=Body segment; 7=Cirrus.

Examine a prepared slide of a cross section of *Nereis* to identify the ***gut, coelom (body cavity), longitudinal muscles, parapodia and know their functions***.

Observe a live *Nereis* in a dish with the naked eye and under the dissecting microscope. Note the ***blood pulsing through the dorsal blood vessel, which is contractile and serves as a heart, and the other body parts as above.***

Bloodworms (*Glycera dibranchiata*) are shallow water marine burrowing worms that are heavily used as bait for fishing. They have a large ***proboscis***, which can be everted and is used for feeding.

Examine a preserved specimen of the bloodworm. Like the sandworm, this worm is found along the Maine coast and like the sandworm is an active predator. ***Find the structures listed in the key for Figure 5-5***.

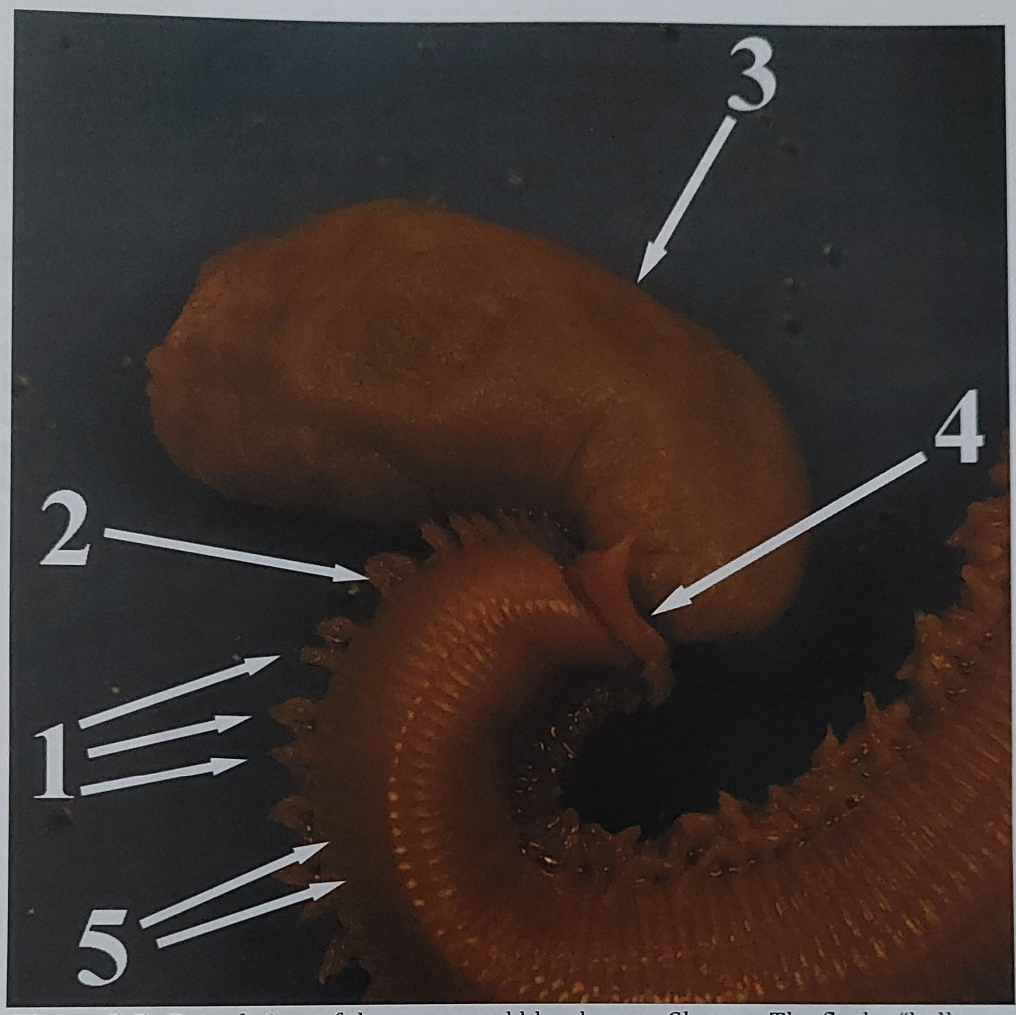

Figure 5-5. Dorsal view of the preserved bloodworm *Glycera*. The fleshy "balloon-like" structure at the anterior end is the everted proboscis. Key: 1=Setae; 2=Parapodia; 3=Proboscis; 4=Head; 5=Body segments.

Ask the instructor about dissecting a bloodworm and sandworm: find the proboscis, gut and body cavity.

B. ***Deposit feeders*: *(you should be able to identify these animals as deposit feeders)*.**

Lugworms (*Areniccola*) are shallow water marine burrowers like bloodworms, but are deposit feeders instead of predators. They range in size from 7- 30cm and spend the majority of their time in the burrow, occasionally swallowing sand.

Examine a specimen of the lugworm and be sure to ***identify the body segments, parapodia, and gills.***

Amphitrite are surface ***ciliary deposit feeders*** with tentacles at the head region of the worm. The head region is at the surface of the substrate while the body of the worm is normally in its burrow.

Examine the specimen of *Amphitrite* (Figure 5.6). ***Find the feeding tentacles, gills, and parapodia.***

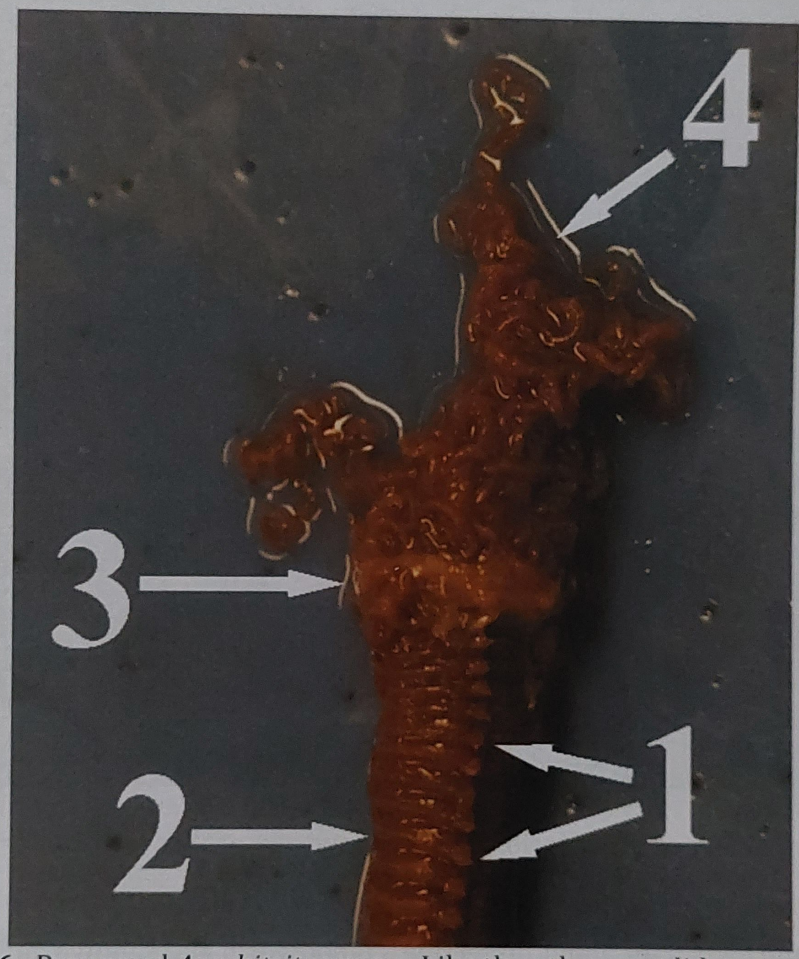

Figure 5-6. Preserved *Amphitrite* worm. Like the other annelid worms you have observed today, it has parapodia running along the sides. The feeding tentacles are obvious in this specimen. Key: 1=Parapodia; 2=Segment; 3=Peristomium; 4=Tentacles.

C. ***Filter feeding polychates: (you should be able to identify these animals as filter feeders).***

These worms use ciliated tentacles to filter food particles from seawater.

Spirorbis are small worms that have a white, coiled shell. They usually are attached to seaweeds, rocks, shells or other hard substrates.

Examine live *Spirorbis (if available)* with the aid of your dissecting microscope. Find ***the calcareous shell and the feeding tentacles***. If you watch carefully, you will note particles in the water being drawn through the feeding tentacles!

Part 4. Phylum Nemertea *(=ribbon worms).*

These animals superficially resemble flatworms except that they have a ***complete gut***; i.e. a mouth and an anus, and the large ***eversible proboscis*** is at the anterior end and is not connected to the gut. The proboscis is used to capture prey. Ribbon worms respire across their skin and the smaller species move via ventral cilia on a trail of slime while the larger species move via muscle action. Most ribbon worms are carnivores with some species being scavengers. They are bottom dwellers, burrowing in sediments or living in crevices of rocks or reefs.

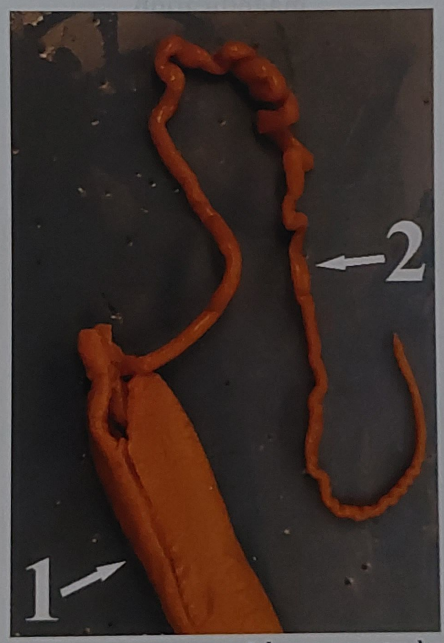

Figure 5-7. Image of a nemertean worm with an everted proboscis. Key: 1 = Body; 2 = Proboscis.

Examine the slides of nemerteans and preserved specimens from Casco Bay.

Part 5. *Meiofauna*

This term is used to describe a variety of small invertebrates that live between the grains of sand and mud. Examine the prepared slides of rotifers and make wet mounts of living rotifers and the "mixed invertebrate" culture. Examine the slides with your compound microscope. Don't forget to start at the lowest magnification on your microscope, 4x. See how many different types of animals you

can find. For additional details see pages 363-365 in your textbook.

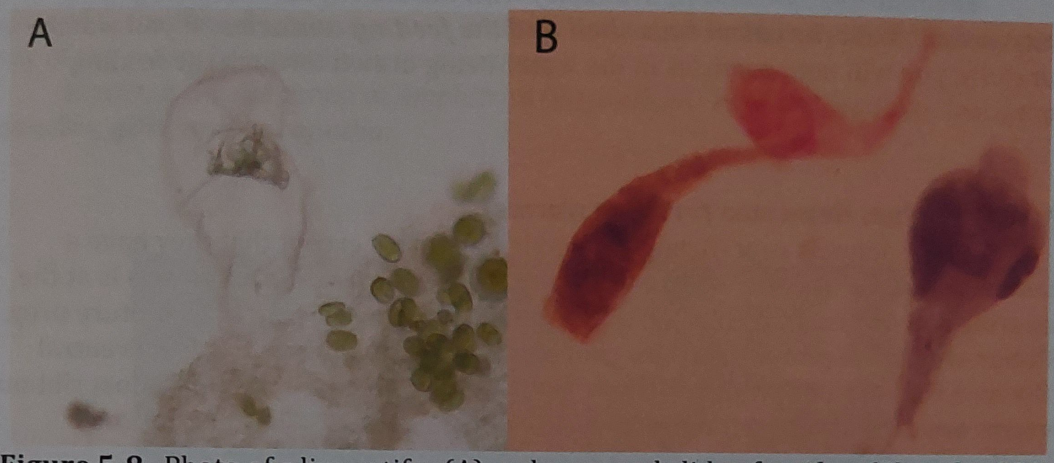

Figure 5-8. Photo of a live rotifer (A) and prepared slide of rotifers (B) under 200x magnification.

Questions

1. What are some differences between the sand worms and blood worms you examined in lab? What are some similarities?

2. How do the feeding strategies of the worms you examined today differ from each other and what were some examples of each?

3. What were some key differences between the different phyla you examined?

4. What is meant by the term "free-living"?

5. How are the lifestyles of the parasitic organisms you viewed today similar? How are they different?

6. How do the live planaria react to light?

Laboratory 6: Molluscs

Part 1. Introduction

Molluscs are the second largest phylum of animals and are a diverse group of organisms that includes scallops, mussels, squids, snails, and sea slugs, among others. They also play an important part of marine ecosystems including being part of the marine fouling community, rock reef systems, coral reef systems, as well as the pelagic zone. They are as diverse in how they acquire food as the environmental niche they occupy.

In lab we will examine members, or at least their remains, of five of the seven classes of molluscs. This is a difficult group of animals to get a handle on because the classes do not look much alike. For example, a squid does not look anything like a clam. What they all do have in common is head-foot and visceral mass.

Part 2. Class Polyplacophora *(= chitons)*

Chitons are found worldwide in cold, warm, and tropical waters living on hard surfaces. They have eight shell plates that compose their shell. Find the following on the preserved specimen: ***mouth, gills, foot, girdle, shell plates (where visible***). One specimen (*Katharina*) has the shell plates visible on its dorsal surface, while the large "gum shoe" chiton (*Cryptochiton stellerai*) has the shell plates covered by the girdle.

Part 3. Class Scaphopoda (*tusk shells*)

The name tusk shell is derived for this organism's resemblance to an elephant's tusk. They burrow in the soft sediment of the subtidal habitat. They are ***selective deposit feeders***.

Examine the tusk shaped shell (see Fig. 9-6, page 218 in the textbook).

Part 3. Class Gastropoda *(=snails & slugs)*

This is an extremely large group of diverse animals that live in marine, freshwater, and terrestrial environments. The number of species in this class is second only to insects. This class of molluscs include organisms with an external shell (snails) or without one (slugs).

In the marine environment, they are found worldwide in all waters and occupy numerous ecosystems including coral reefs, rocky shores, mudflats, and estuaries.

Beyond anatomy common to other molluscs, gastropods have eyes at the end of eye-stalks (called "tentacles") and a radula, which the organism uses in feeding. The radula is toothed and is adapted for the types of food the organism consumes. These organisms can have toxins or even acids associated with the radula and in cone snails, it is modified as a venomous harpoon.

Examine the cut open shells and note their geometric precision. We will examine several locally found gastropods. You will need to be able to identify the organisms by their type of feeding.

A. ***Herbivorous snails***

Limpets and ***periwinkles*** use their radula to scrape algae from rocks and other substrata. Limpets are dorso-ventrally flattened and they use their foot for suction to help them adhere to rocks or other hard substrata. The tortoiseshell limpet is one commonly found in Maine.

There are several species of periwinkles found in Maine. The ***common periwinkle*** has a thick, dark-grey to brown shell and is ubiquitous along the rocky shoreline. These snails are an invasive species that have adapted to take over their ecosystem.

The rough periwinkle is smaller than the common periwinkle with a yellow to gray color, while the smooth periwinkle is about the same size as the rough but with a brownish yellow or orange shell.

Examine the shells of the limpets and periwinkles, noting the differences between them. Also note that the ***aperture*** of the shell lacks a ***siphonal notch*** (see p. 218 of the textbook).

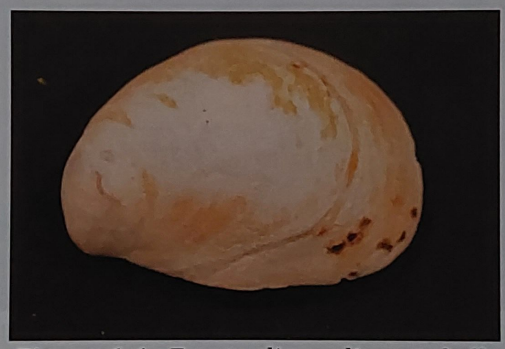

Figure 6-1. Empty slipper limpet shell.

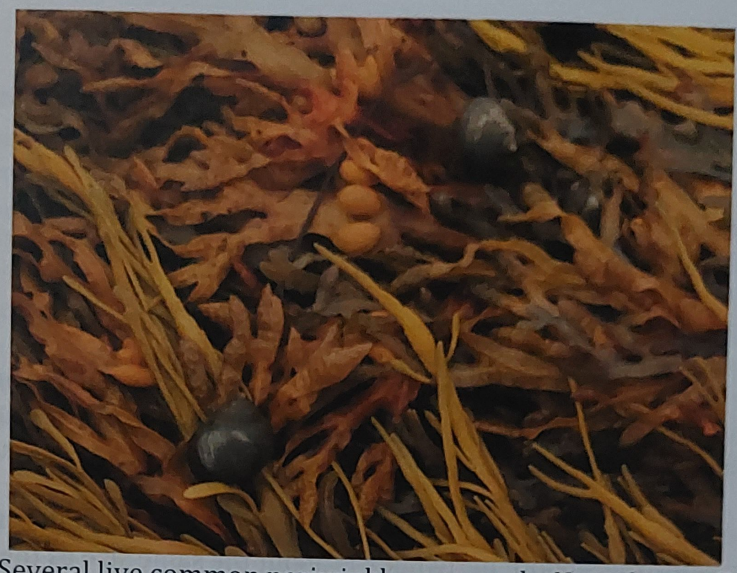

Figure 6-2. Several live common periwinkles on a rock. Note the small barnacles in the background.

Figure 6-3. Live smooth periwinkle crawling on brown algae. Note the tentacles (eye-stalks) on the head.

B. ***Carnivorous snails***

Dog whelks are common in the marine and estuarine environment. Their shell is small and rounded with a pointed spire. Note that the ***apertures*** have a ***siphonal notch (see Atlas)***. Dog whelks use their radula to bore into the shell of organisms and then secrete digestive enzymes and paralytic enzymes into the hole. Then the whelks feed on the "soupy" organism.

Examine the shells of dog whelks and live specimens, if available.

Figure 6-4. Two live white whelk shells attached to a rock. There is also a common periwinkle at the top of the photograph.

Find the following on the live periwinkles and dog whelks: ***shell, foot, operculum, head, tentacles, siphon (on the dog whelk)***.

Be able to identify the radula and whether or not it came from an herbivore or a carnivore.

C. Shell characteristics

Episodic growth: note the ***regular angular appearance*** of the growth increments by examining the shells of a *Murex* and a helmet conch.

Spines: note the spines on the Murex shells - these are an ***adaptation to avoid predation by stingrays***.

Figure 6-5. Spines on a shell. Also notice the coiling on this shell.

Coiling: note the ***right and left "handed" coiling*** in the *Murex* and lightning whelk. This is the result of a ***genetic mutation*** that is considered ***"neutral" in an evolutionary sense***, *i.e.* it has no advantage or disadvantage.

D. ***Sea slugs***

These gastropods are found worldwide in cold, warm, and tropical waters at virtually all depths. The ***absence of a shell in these animals is a secondary trait, i.e. it is more recently derived rather than less recently derived (ancestral).*** Many species are colorful and this color and their texture resembles venomous organisms in its ecosystems as a predator deterrent. Other defense mechanisms include chemical and even "stealing" nematocysts from the cnidarians upon which some species feed.

Examine live ***sea slugs*** if available. Identify the following: ***head, foot, tentacles (on head), cerrata***. If you look carefully at a specimen under a dissecting microscope, you can often see the heart beating through the dorsal body wall of the animal.

Part 4. Class Bivalvia

Bivalves include mussels, scallops, clams, oysters etc. This group of animals, with one or two exceptions, is ***filter feeders,*** and the gills are highly modified to filter particles from seawater. These organisms also differ in their habitat with some burrowing in sediments while others attach to hard surfaces and being part of the fouling community. There are noticeable characteristics that will allow you to determine the habitat type. ***You should be able to figure out where these animals live.***

Attached surface dwellers have heavy shells, some with spines. Both of these adaptations are to reduce or avoid predation. These bivalves have some means of attachment to hard substratum either by ***byssal threads*** (***mussels***; Figure 9-13b, page224 of the textbook) or the shell cemented to the surface (***oysters***).

Unattached surface dwellers are organisms such as the ***scallop***. These have thin shells, which allow them to escape predators with short bursts of swimming.

Shallow burrowers have heavy, robust shells and short siphons. The ***siphon*** is a hollow tube that allows the bivalve to bring in water for respiration and feeding. ***Quahogs*** are examples of shallow burrowers.

Deep burrowers are laterally compressed with thin shells and long siphons. ***Softshell clams*** and ***razor clams*** are examples of deep burrowers.

You should be able to identify the following parts: ***byssal threads (if present), foot, gills, adductor muscle, shell,*** when you examine the bivalves with your lab partner, and also be able to identify where the animal lives.

Examine a quahog , a softshell clam and a razor clam, a scallop, an oyster, and a mussel.

Figure 6-6. Dissected bivalve showing important structures. The gills have been teased away from the foot to expose the digestive tract. Key: 1=Umbo; 2=Shell; 3=Mantle; 4=Adductor muscles; 5=Foot; 6=Gills; 7=digestive tract.

Part 5. Class *Cephalopoda*.

The molluscs in this class have a long fossil record and include the largest invertebrate (the giant squid). All of the members of this class are active predators and most of them are pelagic. Cephalopods have very well developed brains and sensory systems and are the most intelligent invertebrates. They can perform complex behaviors, problem solve, and are clever predators. They have a set of arms or tentacles and are found worldwide in cold, temperate, and tropical waters.

Examine the ***fossil cephalopods*** that are ***most closely related to the chambered nautilus***.

The chambered nautilus is a cephalopod with a shell that has different chambers that are used for buoyancy. The chambers are separated by a wall called a septum and as the nautilus grows, it adds more chambers. They also have many sticky tentacles that lack suction cups like other cephalopods. They live in tropical waters and are primarily nocturnal predators, feeding on fish and invertebrates. They also have a longer life span than other cephalopods.

Examine the shells of the ***chambered nautilus*** (see Figure 9-15, page 199 in your textbook). Find the following: ***septum, chamber, siphuncle opening. Note that the shell is used both for protection and buoyancy.***

Figure 6-7. A cutaway of the shell of a chambered nautilus. The septa separate the chambers and the siphuncle openings are the "holes" in the septa.

Cuttlefish are found in temperate and tropical waters up to a depth of 600m that are active predators on fish, crabs, worms, and other invertebrates including other cuttlefish. They have suckers on their eight arms and the distal ends of their two tentacles. They also have a cuttlebone, which is not a bone at all, but an internal shell made of aragonite. This cuttlebone provides buoyancy for cuttlefish. They can alter their skin color, pattern, and texture via chromatophores.

Examine the ***cuttlefish* (*Sepia*).** Find the same ***external parts*** that you did on the squid (see below). Note the ***internal shell used for buoyancy***. Having an internal shell makes the animal more streamlined and a much faster swimmer than a chambered nautilus.

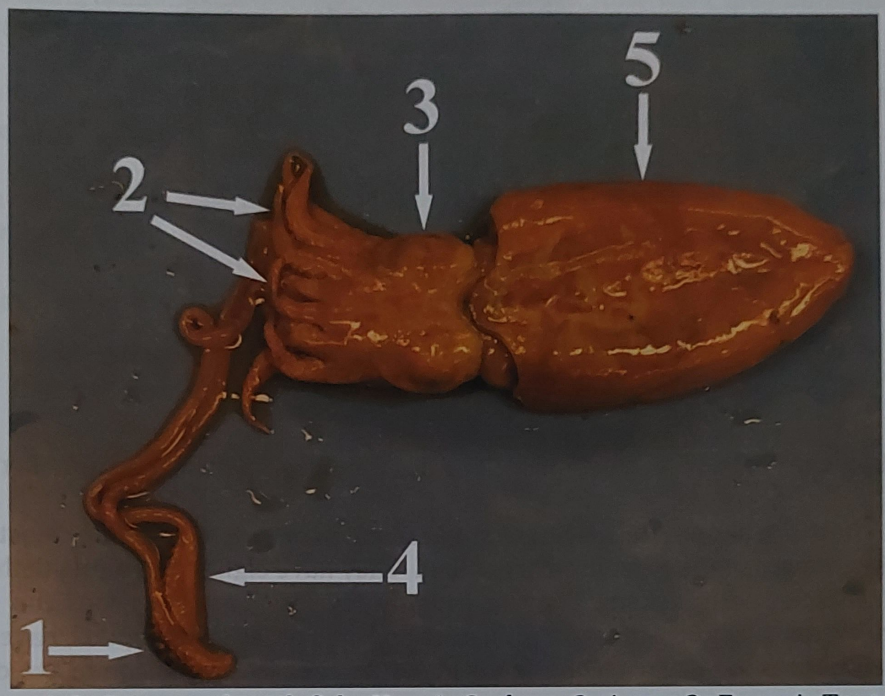

Figure 6-8. Preserved cuttlefish. Key: 1=Suckers; 2=Arms; 3=Eyes; 4=Tentacles; 5=Mantle.

There are over 300 species of ***octopuses*** found worldwide. Most are ***benthic***, but some can be found in pelagic waters. Like other cephalopods, they have highly developed eyes, nervous and sensory systems. They have eight arms with suckers and a beak made of chitin for a mouth. They are active predators on fish and invertebrates and have saliva that is venomous. To escape predation, they use jet propulsion or can expel ink from an ink gland as well as using camouflage by altering their skin color and texture.

Most species of octopuses are short-lived, often dying following reproduction. They can live longer in captivity if reproduction is prevented.

Examine the ***Octopus.*** Find the following: ***mantle, eye, funnel, sucker, arm***. Most octopuses are benthic in contrast to the ***majority of cephalopods, which are pelagic. Note that the shell is totally lost in octopuses.***

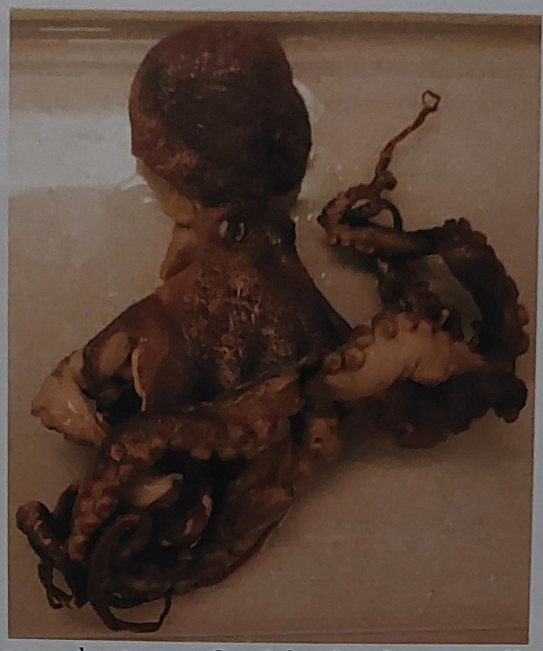

Figure 6-9. Preserved octopus. See Atlas for close-up of beak and suckers.

There are about 300 species of ***squid*** found in oceans worldwide. Most are active swimmers in the pelagic environment. They have eight arms along with two, longer tentacles with suckers. They have highly developed eyes, nervous and sensory systems. Squid are active predators and, like other cephalopods, have chromatophores to change colors, an ink gland, and use jet propulsion to avoid predation.

The squid is used extensively in neuroscience in part because of the ***giant axon***. Research on the giant axon includes ionic mechanisms and action potentials as well as anterograde and retrogade transport of various compounds.

With your lab partner, examine and dissect a squid. Find the following: ***mantle, fin, eye, funnel, arm, tentacle, sucker, beak.*** Also note the ***cartilage rings*** with ***teeth*** lining the suction cups. Examine one under your dissection scope. Use your scissors and cut open the ventral mantle of the squid from the funnel to the fins, find the ***gills***, ***ink sac*** and the ***pen*** (see the picture on page 226 of your textbook). Cut open the head and find the ***beak***. ***To get credit for attendance at today's lab, show me your dissection of the squid!***

Questions

1. What ties the various classes together into Phylum Mollusca?

2. How were the bivalves you examined today similar to each other (don't discuss just the shell, examine the internal anatomy as well)? How were they different from each other?

3. Did the shells of the gastropods you examined give you any hints to their lifestyle and feeding? Why or why not?

4. The cephalopods available in lab today were numerous and varied. What were the similarities and differences among them?

5. What was the gender of your squid? How many hearts does a squid have?

Laboratory 7: Arthropods

Part 1. Introduction to *Phylum Arthropoda*.

Animals in this phylum all have an ***exoskeleton*** composed of chitin, a segmented body, and ***jointed appendages***. In comparison to molluscs, arthropods are relatively easy to recognize. They consist of the most numerous and diverse animals on the planet and include insects, arachnids, and crustaceans.

You will examine examples of three of the four subphyla: trilobites (all extinct now), chelicerates, and crustaceans.

Part 2. *Jawless arthropods: trilobites, horseshoe crabs, and sea spiders.*

Trilobites are one of the earliest groups of arthropods. From the fossil record, it was determined that they had a wide geographical distribution (all in the marine environment) as well as being a highly diverse group of organisms.

Examine a fossil ***trilobite*** and find the ***head (=cephalon), thorax, and abdomen (=pygidium)***. Examine one of the specimens under a dissecting microscope and observe the ***compound eyes***.

A. Subphylum Chelicerata

Chelicerates in the marine environment include horseshoe crabs and sea spiders. The body segments consist of a cephalothorax and abdomen. This group of organisms can be predators, herbivores, scavengers, parasites, and detritivores.

Horseshoe crabs are found in shallow ocean waters with sandy or mud substrata and they come onshore to mate. They feed on crabs, worms, and other invertebrates. Like the trilobites, these organisms also have compound eyes. They do not have antennae, nor do they have mandibles, which is why they are classified as chelicerates and not crustaceans. In fact, they are more closely related to spiders and scorpions than they are to crustaceans.

Various species of shorebirds feed on the eggs and larvae and the hard carapace provides a settling place for barnacles, sponges, and some molluscs.

Examine a ***horseshoe crab*** and find the ***head (= prosoma), abdomen, lateral eyes, legs, and book gills*** (Fig. 9-31, page 236 textbook). Note the difference in the ends of the first walking legs in males and females - ***the hook-like ends in the smaller male are used in reproduction***.

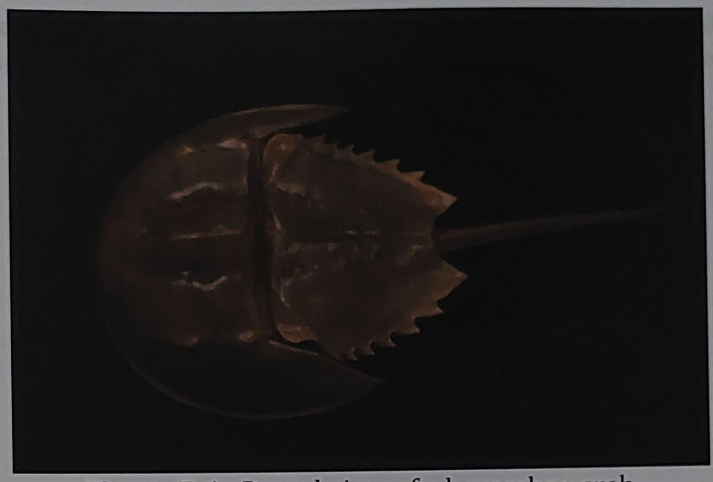

Figure 7-1. Dorsal view of a horseshoe crab.

Sea spiders are found worldwide in cold, temperate, and tropical waters. There are over 1300 species with most species being small and living in shallow waters. They have four to six pairs of walking legs and gases diffuse across the body. Most are predators or scavengers on sponges, jellies, and other invertebrates.

Examine a ***sea spider*** if available. These odd arthropods are common on local hydroids.

Part 3. ***Jawed arthropods: crustaceans*** **and insects.**

A. Subphylum Crustacea

In comparison to the other subphyla of arthropods, ***crustaceans*** display a great diversity of body plans. They have a variable number of segments and appendages, but they all have ***mandibles*** and two pairs of antennae, although these traits may be hard to recognize. In addition, the body is often divided into a ***cephalothorax*** (***head*** and ***thorax*** fused together) and an ***abdomen***. Appendages on the thorax are often legs, while those on the abdomen are smaller and are often used for swimming. You will examine a variety of crustaceans, and their larval forms, that are found locally.

I. Larval forms. Examine the slides of the baranacle nauplius (see Atlas) and the crab zoea and megalops. Be able to recognize these as ***crustacean larvae***.

II. ***Copepods***. These very small crustaceans are found worldwide in the marine and freshwater environments. Copepods are an important part of the zooplankton as well as in the benthic environment. In addition, many of them are found in fouling communities associated with hydroid colonies. They are an important part of the food web, feeing on a mix of algae and are fed on by fish, seabirds, whales, and crustaceans.

Examine the slide of *Cyclops* and find the following: ***antennae, head and thorax, abdomen,*** and ***eye***. Examine any live specimens with your dissecting microscope.

Figure 7-2. Microscope image of *Cyclops* sp under 50x magnification.

III. *Amphipods*. These ubiquitous crustaceans form a huge assemblage of species ranging in size from 5 to 200mm and have a worldwide distribution in marine plankton and benthos. Most amphipods are laterally compressed with a head, thorax, and abdomen. Females have a brood pouch to house the fertilized eggs until they are ready to hatch. Amphipods are scavengers, detritivores, predators, grazers, and omnivores.

Examine the slide of *Gammarus.* Find the following: ***antennae, eyes, head, thorax , abdomen , claws*** (= chelipeds or , = gnathopod), ***walking legs, abdominal appendages*** (=pleopods).

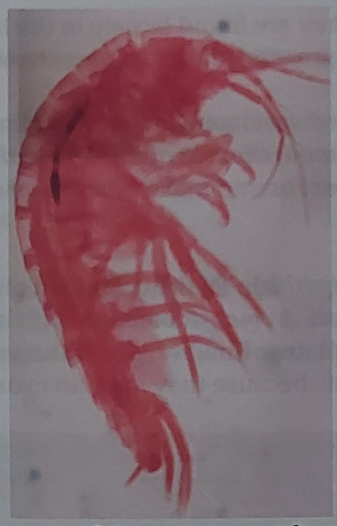

Figure 7-3. Microscope image of *Gammarus* sp taken under 50x magnification.

Observe any live specimens with your dissecting microscope. Examine the live ***skeleton shrimp*** (if available), which are not shrimp at all but amphipods. Note the brood chamber for eggs and you may also see the heart beating (it lies dorsal to the gut).

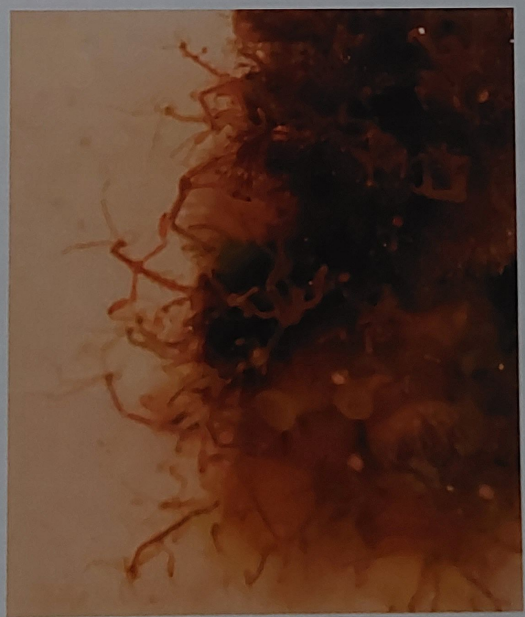

Figure 7-4. Live skeleton shrimp on a mussel.

IV. ***Isopods*** are almost as numerous as amphipods and are also about the same size range. Isopods are dorso-ventrally flattened with about 4500 species in

the marine environment. They are found largely in the benthic environment and even in tidepools. They are grazers, predators, detritivores, and even parasites.

Examine the preserved specimen and also any living specimens. Find the following: ***antennae, eyes, head, thorax, abdomen, walking legs, abdominal appendages***. Notice that there are no big claws on the isopod in comparison to the amphipods.

V. ***Barnacles (=Cirripedia).*** To the untrained observer, barnacles do not appear to be crustaceans at all. In fact, at one time they were thought to be molluscs because of their calcareous plates. However, examination of the internal anatomy shows them to be crustaceans because they have an exoskeleton and jointed appendages.

Barnacles are exclusively marine, sessile organisms that live in shallow and tidal waters and are part of the fouling community. They settle on a hard substrate (rocks, docks, bivalves, and even large marine animals) as larvae and grow their shell around them (or in some species, attach themselves to the substrate via a stalk). Their shells help protect the organism from predation and desiccation.

Barnacles are highly modified ***filter feeders***. They compete with other barnacles, mussels, and limpets for space. Most are hermaphroditic but do not self-fertilize.

Examine the preserved specimen of a goose barnacle. Locate and know the function of the ***stalk, shell plate, thoracic appendage*** (= cirriped). See Figure 9-41, page 242 of the textbook.

Figure 7-5. Barnacles on a rock.

Observe feeding in a live acorn barnacle with your dissecting microscope.

VI. ***Mantis shrimp*** are predatory crustaceans in shallow tropical and sub-tropical waters with large, powerful chelipeds (claws) to capture prey. They may grow as large as 30-38cm and typically burrow in soft substrates. They can be aggressive with most species being solitary.

Examine a preserved mantis shrimp. ***Be able to recognize this animal as a predatory crustacean. Identify the following: eyes, antennae, claws*** (=chelipeds), ***walking legs, abominal appendages, cepahlothorax (head and thorax) abdomen, tail fan.***

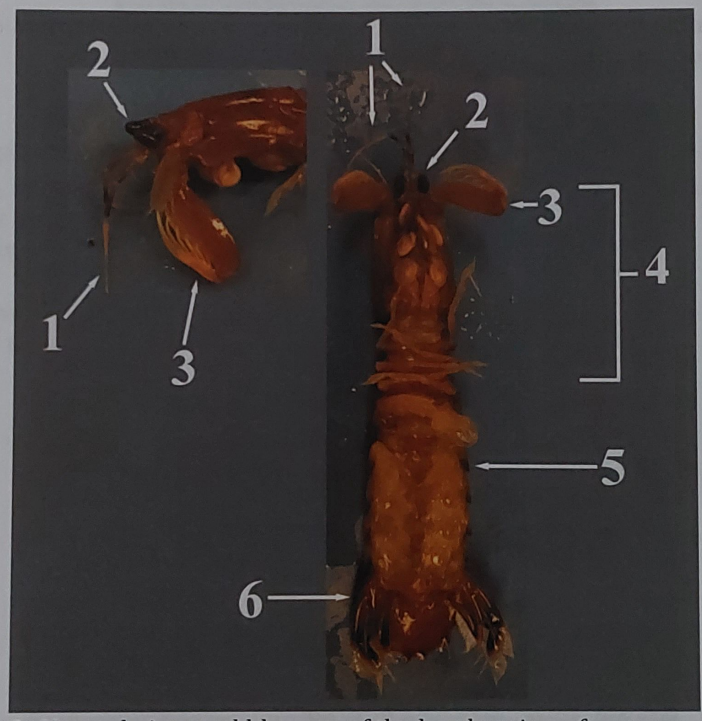

Figure 7-6. Ventral view and blow up of the head region of a preserved mantis shrimp. Note the well-developed claws for prey capture. Key: 1=Antenna; 2=Eye; 3=Claw; 4=Cephalothorax; 5=Abdomen; 6=Tail fan.

VII. ***Decapoda***. These organisms are much more familiar marine crustaceans and include crabs, shrimp, lobsters, and prawns. They live in a wide range of marine environments and most are scavengers. All have five pair of thoracic appendages with an additional three pair on the head forming modified mouthparts. In some species, they have chelipeds (claws) and abdominal

appendages.

Maine shrimp (or Northern shrimp) are found on soft bottoms in cold waters of the Atlantic and Pacific oceans. They can grow up to 120-165mm and are an important marine fishery.

Examine any preserved or "fresh" Maine shrimp and note the similarities to and differences from other decapod crustaceans.

Sand crabs are also known as mole crabs can be found worldwide except in Polar Regions. As the name implies, they live in sandy substrates and use their legs to dig into the substrate. They are filter feeders that use their ***antennae as filters*** (see Figure 13-24, page 362 of the textbook).

Examine the preserved sand crab and note the similarities to and differences from other decapod crustaceans.

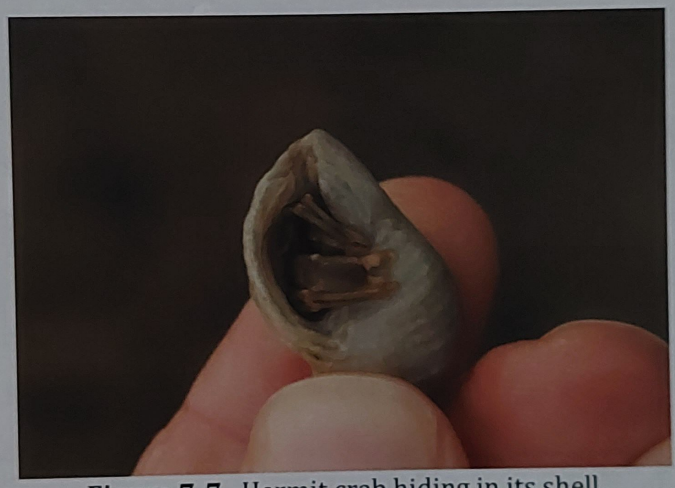

Figure 7-7. Hermit crab hiding in its shell.

Figure 7-8. Preserved sand crab.

Spider crabs also have a worldwide distribution. They are predators and have spines on their ***carapace*** for protection. They live on various substrates and

the adults are non-aggressive.

Examine the examples of spider crabs and note the similarities to and differences from other decapod crustaceans.

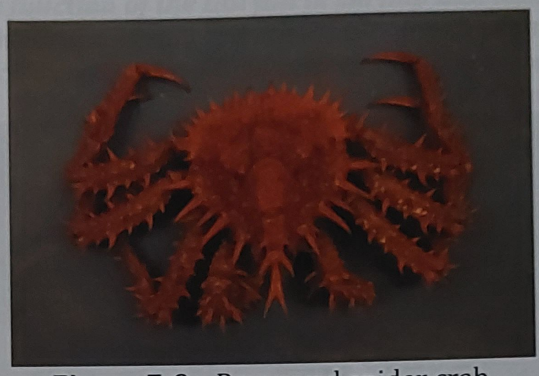

Figure 7-9. Preserved spider crab.

Fiddler crabs are small decapod crustaceans found in salt marshes, mangroves, and on soft bottoms. They are detritivores with a ***sexual dimorphism: males have one large claw used for fighting with other males*** and for communication.

Examine the examples of fiddler crabs and note the similarities to and differences from other decapod crustaceans.

Figure 7-10. Preserved fiddler crab. Note the one large claw.

Jonah crab (or Cancer) is found along the eastern coast of North America. It is a non-aggressive crab with strong claws and there is a small-scale fishery for these organisms.

Blue crabs are found all along the western Atlantic Ocean and form an

important fishery. These crabs also exhibit a sexual dimorphism but it is not with the chelipeds. Instead, the males have a long, slender abdomen while females have a wide, rounded abdomen. They are omnivores and are preyed upon by sharks, rays, and several species of bony fish.

Examine the examples of blue crabs and note the similarities to and differences from other decapod crustaceans. Note the ***last pair of walking legs modified for swimming***.

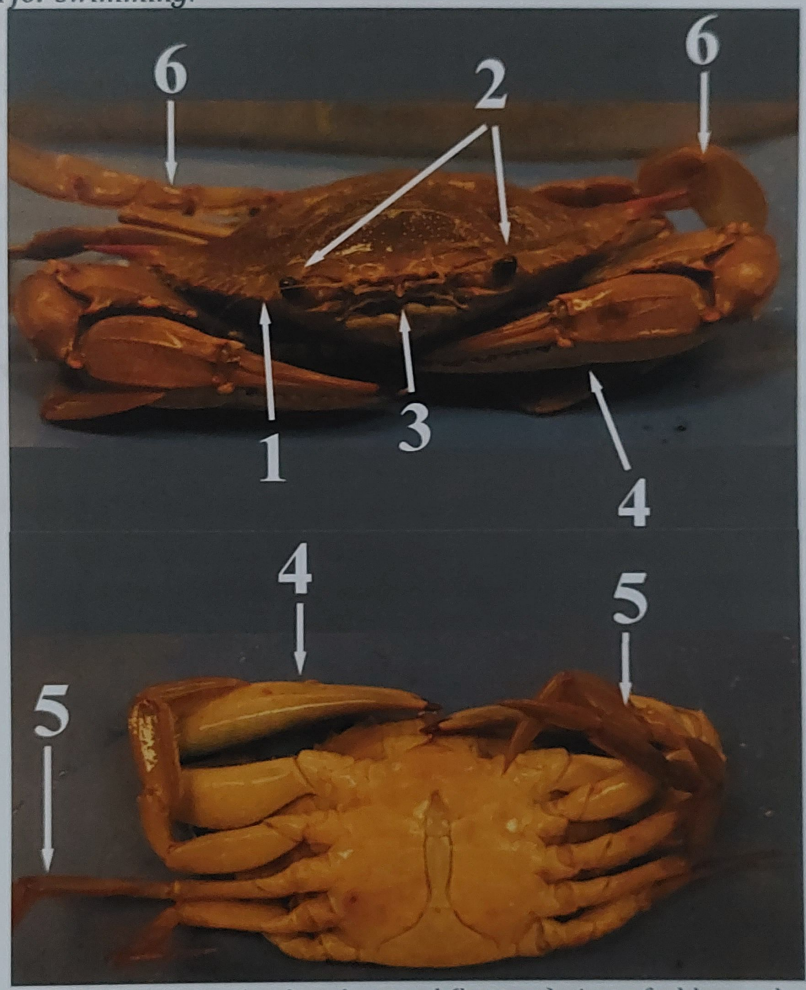

Figure 7-11. Anterior (top) and ventral (bottom) view of a blue crab. Key: 1=Antenna; 2=Eyes; 3=Mouth; 4=Claw; 5=Walking legs; 6=Swimming legs.

VIII. Crab dissection. Find the following body parts on the cancer crab: ***carapace, abdomen, antennae, thoracic appendages (including*** chelipeds ***(claws) and walking legs), adominal appendages (swimmerets)***. Cut open the crab by placing a shucking knife between the carapace and the abdomen, then prying up the

carapace. Use the picture to find the internal anatomy: ***gills, heart, digestive gland and stomach. You must show me your dissection to get credit for attendance in today's lab. In addition, know the function of the antennae in the sand crab, and its mode of feeding. Know the function of the last pair of thoracic legs in the blue crab. Know the function of the tail fan in shrimp and lobsters. Crack open one of the large claws and note the tendon like structure that attaches the claw muscles to the claw. Also note the articulation of the joints on the walking legs.***

Questions

1. Based on external morphology, what would you guess is the typical ecosystem for horseshoe crabs?

2. How many sets of eyes did you find on the horseshoe crab? On the blue crab? On the copepod? What are their functions?

3. What are the functions of the various appendages found on the organisms you observed today?

4. What methods of anti-predation were visible in each of the classes you observed today?

5. Compare and contrast the external morphology of the decapod crustaceans you observed today and how that morphology affects their lifestyle.

6. How is the mantis shrimp different from the northern shrimp you examined today?

Laboratory 8: Echinoderms

Part 1. Introduction to *Phylum Echinodermata*.

Adult animals in this phylum are characterized by five-fold ***radial symmetry***; however, the larvae exhibit bilateral symmetry. In addition, the phylum is characterized by a ***water-vascular system used for feeding and locomotion, and the presence of dermal branchiae or skin gills.*** This water vascular system is composed of canals that connect to numerous tube feet, which are sucker-like. When echinoderms contract certain muscles, they force water into their tube feet, which causes them to extend. When the muscles are relaxed, the tube feet contract. This system allows the echinoderm to move across multiple types of substrata and allows predatory species latch onto prey.

The echinoderm skeleton is composed of calcareous plates called ossicles, which are joined together by tissue or fused, in some cases. Echinoderms also have powerful abilities to regenerate lost arms and organs.

Like the molluscs, animals in this phylum are somewhat difficult to characterize since the members of the different classes don't much look like each other. The major groupings of animals have the rank of class: ***Asteroidea (sea stars), Ophiuroidea (brittle stars), Crinoidea (feather stars), Echinoidea (sea urchins and sand dollars), and Holothuroidea (sea cucumbers)***.

A. ***Feather stars (crinoids)***

Feather stars live mostly in deep waters (up to 6,000 meters) but some can be found in shallow waters. Feather stars are ***filter feeders*** with their mouth on the top surface and they normally have more than five arms. Unlike other echinoderms, the water vascular system of feather stars is not connected directly to external seawater. Most modern feather stars are free-swimming.

Examine the skeletal remains of the feather star. Be able to identify the ***oral surface, arm, ambulacral groove, mouth, and pinnule***.

Examine the cast of fossil crinoids.

B. ***Brittle Stars*** (ophiuroids)

Ophiuroids have a worldwide distribution living at various depths. Brittle stars can grow up to 60cm in length and use their arms to crawl across the substrate. The central disc of brittle stars is much more sharply demarcated from their arms than sea stars. Brittle stars also lack the ambulacral groove of sea stars. Brittle stars are scavengers and detritivores and may prey on small invertebrates.

Examine preserved specimens of the brittle stars. Locate and be able to identify the ***arms, disc, oral surface, aboral surface, mouth***.

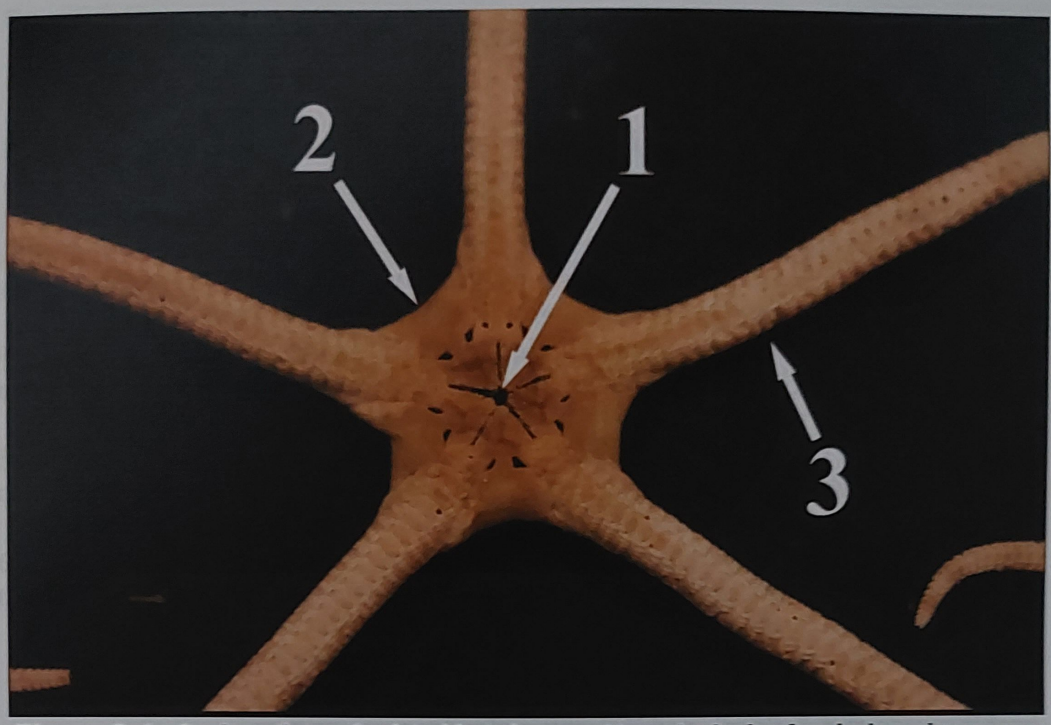

Figure 8-1. Oral surface of a dried brittle star. Note the lack of ambulacral grooves in the arm. Key: 1=Mouth; 2=Disc; 3=Arm.

C. ***Sea Cucumbers*** (holothurians)

Sea cucumbers have an elongated body that doesn't appear to be related to other echinoderms at first glance. However, due to anatomical similarities, they are often said to be echinoderms lying on their side. They have five ambulacra separated by five ambulacral grooves. They are typically 10-30 cm in length.

They are found on the sea floor worldwide and are generally scavengers. There are a few species that are pelagic. Like other echinoderms, they have powerful regenerative capacities. In some species, they will shed their internal organs as predator deterrence and will regrow those organs in a short period of time.

Examine the preserved sea cucumbers and find the ***ambulacra, tube feet, mouth, anus, body, oral tube feet (oral tentacles), oral end, aboral end. Know the mode of feeding.***

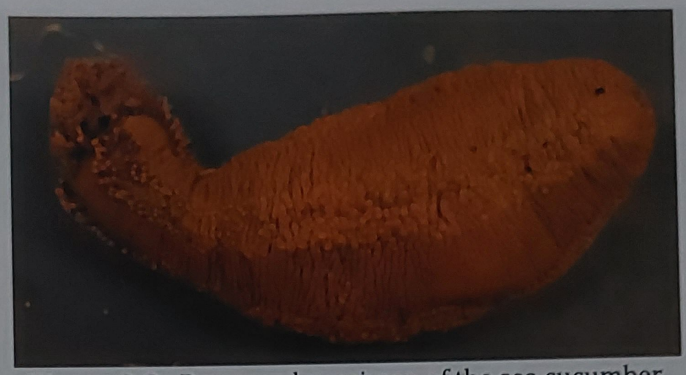

Figure 8-2. Preserved specimen of the sea cucumber.

D. ***Sea Stars (= starfish,*** Asteroidea)

Sea stars are found in all oceans worldwide from the poles to the equator. They also occur over a broad depth range from the intertidal to abyssal depths. They have a central disc with five arms. They are predators on benthic invertebrates and readily regenerate arms that are lost and can even regenerate the rest of their body, provided part of the central disc remains. Sea stars can have a significant impact on local invertebrate populations and the crown-of-thorns star can decimate coral reefs.

See the Atlas and Figure 9-43, page 244 in your textbook for details; in addition know the function of the items listed.

Examine the slide of the starfish larval stages.

Examine the slides of the starfish arm (cross section) and find the following: ***radial canal, ampulla, ossicle (bony plates), tube foot, digestive gland, gonad.***

Examine the slide of the starfish ***pedicellariae- know their function.***

Examine a live specimen of a starfish and find the ***oral surface, aboral surface, mouth, madreporite, tube feet***. Look at the ***aboral*** surface of a small starfish with your dissecting scope and find the ***pedicellaria***. Know the type of ***feeding. Know the difference between the oral and aboral surfaces.***

Figure 8-3. Aboral view of a dried sea star.

E. ***Sea Urchin*** (= Echiniodea)

Sea urchins are found in all oceans worldwide from the intertidal to depths of 5000m. They are small with color variations in their test and with spines as a predator deterrent. They feed mostly on algae, using their mouth to scrape it from hard surfaces. They have a mouth with calcium carbonate teeth forming a chewing organ called Aristotle's Lantern.

Examine the live specimen of a sea urchin. Locate and know the function of, the ***spine, pedicellaria, tube feet, and mouth.*** You should examine the animal under a dissecting microscope to find some of the smaller items, *e.g.* pedicellaria.

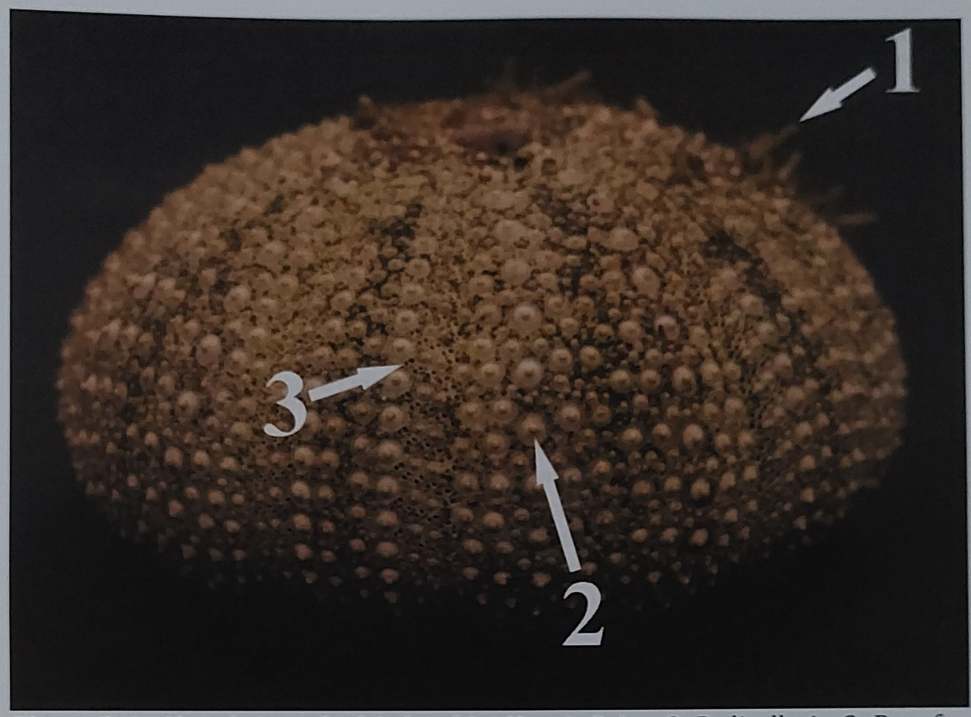

Figure 8-4. Aboral view of a dried urchin. Key: 1=Spine; 2=Pedicellaria; 3=Pore for tube foot.

F. ***Sand dollar (= Echinoidea)***

Sand dollars are flat, burrowing urchins living in shallow coastal waters in all oceans of the world. They bury in the sand with their mouth and test in the water column, capturing food with their tube feet and moving it down food tracts to their mouths via cilia.

Examine the preserved specimen of the sand dollars. Find the ***oral and aboral surfaces, petals, mouth***

Questions

1. What were some morphological differences between brittle stars and sea stars?

2. What are the similarities between sea stars and urchins and sand dollars that have them classified in the same group?

3. How were the tube feet of the live urchin and live sea star similar? How were they different?

4. Based on their morphology, what would the lifestyle and ecology of each of these organisms be?

5. How were larval stages of sea stars different from the adult sea star? How were they similar?

Laboratory 9: Chordates 1

Phylum Chordata is characterized by the following at some point in the life cycle: ***dorsal hollow nerve chord, notochord, pharyngeal gill slits, post anal tail, segmental muscles, and a body cavity***. There are three subphyla, which don't much look alike***: tunicates*** (Tunicata)***, lancelets (Cephalochordates), and vertebrates*** (Vertebrata).

Part 1. Subphylum Tunicata

Tunicates were once classified as urochordates, but we will use the current taxanomic classification. They are found worldwide from the Polar regions to the tropics with most living in depths of 200m or shallower.

They are either single or colonial; moreover, the adults don't look much like a chordate, but the larvae have typical chordate traits. Most adult ***tunicates*** are filter feeders and most of them are sessile, taking in water for respiration and feeding through an incurrent siphon and expelling it through an excurrent siphon. A few species are free-swimming in the plankton.

Examine the slide of the tadpole larva (see the picture the lecture handout). ***Be able to identify this animal as a chordate***.

Examine a live solitary tunicate (sea squirt). Find the following: ***tunic, siphons***. See Figure 9-52b, page 250 of your textbook.

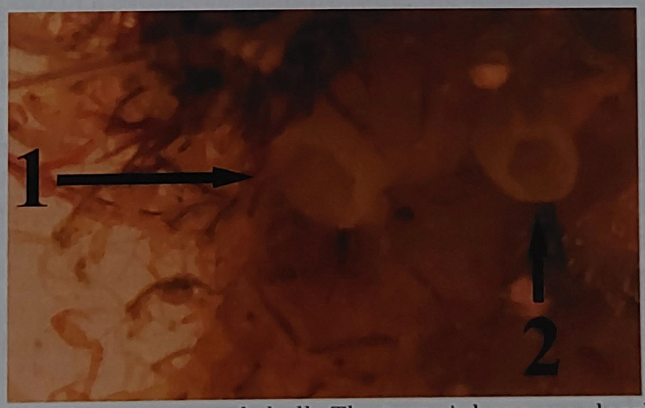

Figure 9-1. Sea Squirt on a mussel shell. The two siphons are clearly visible. Note the larger inhalent siphon on the left and smaller exhalent siphon on the right.

Examine the colonial tunicate (compound sea squirt), if available.

Part 2. Subphylum Cephalochordata

Lancelets (Amphioxus) are distributed worldwide in shallow temperate and

tropical waters. They are small (5-7cm) with a translucent body and no paired appendages. They are found in coarse sand where they bury with their head sticking out to feed. Like the tunicates, lancelets are ***filter feeders*** but they are fish-like and able to swim.

Examine the preserved specimen and whole mount slide of Amphioxus (use your dissecting microscope for the slide). See Figure 9-53, page 251 in the textbook and the handout given out during class. Find the ***pharynx (with gill slits), notochord, nerve chord, head, tail***.

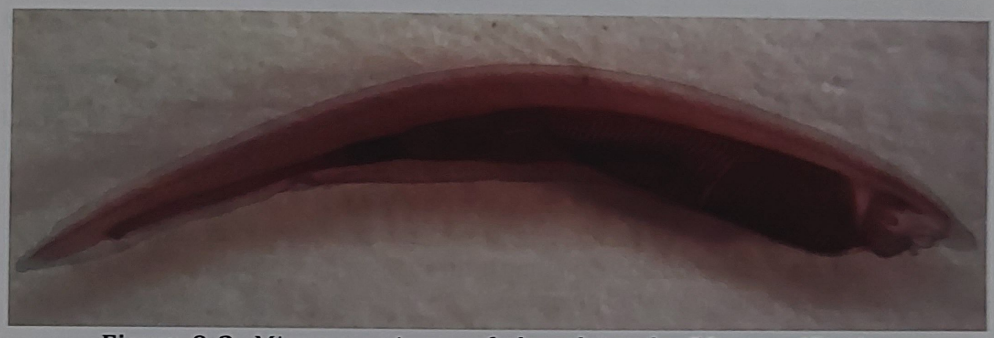

Figure 9-2. Microscope image of a lancelet under 50x magnification.

Part 3. Subphylum Vertebrata

We will examine two groups of ***vertebrates*** today: ***jawless fishes*** (Agnatha), and ***cartilaginous fishes*** (Chondrichthyes). You'd think that all the animals in this group would have a vertebral column (backbone or spinal column), given their name, but this is not the case; hagfish do not have a vertebral column, and the lampreys have a very rudimentary one. A better unifying trait for this group of animals is that the brain is always encased in a skull (cranium). The reason the group is known as vertebrates, as opposed to craniates, is a historical accident.

A unifying trait within the fishes you will observe today (and the bony fishes you will see next week) is that they have an additional sensory system called the lateral line. The lateral line consists of hair cells (structurally similar to those of the inner ear) in a gelatinous matrix that detect water movement across the skin. These organs may be in a canal system or in small "pits" in the head or along the body. Fish use the lateral line in prey detection, social behavior, and predator avoidance.

A. ***Jawless fish: lamprey***

Lampreys live in coastal and fresh waters as well as traveling significant distances in the open ocean. They have been shown to be invasive into freshwater lakes, often devastating native ecosystems.

Lamprey are eel-like in body form, lack paired fins, and lack scales. Parasitic lampreys have a mouth with numerous rows of sharp teeth that they use to attach to the sides of other organisms.

Examine the slide of the ***larval lamprey*** (ammocetes larva): compare to the larval tunicate. Be able to identify this as a ***chordate larva***.

Examine the preserved specimens of the lamprey. Note the absence of jaws and paired fins along the body. Find the mouth and gill slits. Know the feeding mechanism.

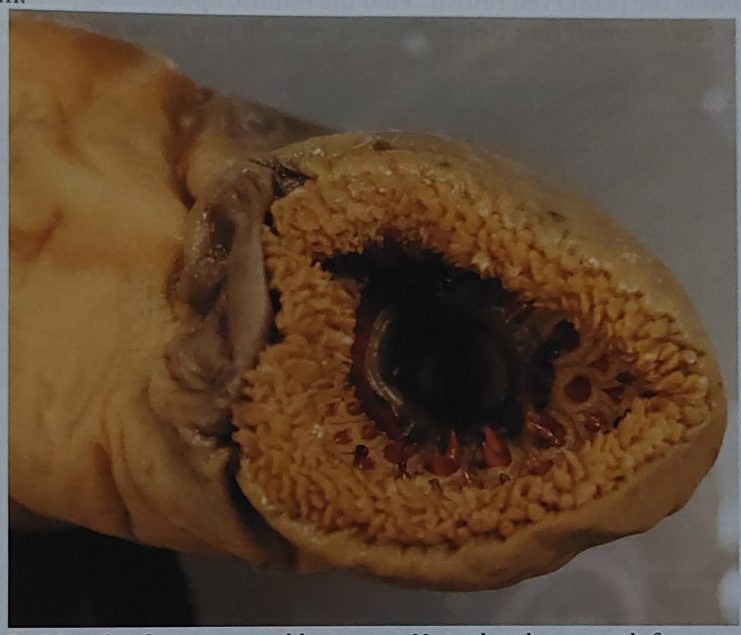

Figure 9-3. Mouth of a preserved lamprey. Note the sharp teeth for attachment to the side of a fish or mammal.

B. ***Jawless fish: hagfish***

Hagfish also have an eel-like body form and are found in temperate regions worldwide in depths over 20m. They produce a great deal of slime as a defense mechanism against predation and feed on invertebrate worms on the ocean floor as well as scavenging dead and dying organisms.

Hagfish lack scales, paired fins, and dorsal fins. They also have no vertebra; instead having a simple notochord connected to a brain set in fibrous tissue. Because of these characteristics, classification over the years has been problematic.

Examine the preserved specimens of the hagfish. Note the absence of jaws and paired fins along the body. Find the following: ***mouth, gills slits***. Know the feeding mechanisms of both.

C. ***Jawed fishes: cartilaginous fish***

As the name implies, these fishes have a skeleton of cartilage. Organisms in this group include chimaeras (***ratfish)*** and elasmobranchs (***sharks, skates, and***

rays).

Ratfish live in temperate oceans to depths of 2,600m with few at depths less than 200m. Ratfish possess scales and have a venomous spine for defense. Rather than teeth, they have grinding plates used to feed on clams, worms, sea stars, fishes, and arthropods.

Examine the preserved ratfish. Find the ***mouth, operculum, pectoral fins, dorsal fins, tail (caudal) fins, pelvic fins, claspers (if you have a male), and the lateral line.***

Figure 9-4. Arrows indicating the electrosensory pit organs (ampullae of Lorenzini) in the snout and under the jaw of a preserved spiny dogfish.

There are over 900 extant species of elasmobranchs. In addition to the sensory systems found in other fishes, elasmobranchs have an electrosensory system. Like the lateral line, these are hair cells in a gelatinous matrix, though all are in "pits" on the dorsal and ventral surfaces of the head or head region of the organism. This system detects small electric currents in the water and can be used to locate prey, avoid predators, find mates, and navigate the oceans (a sort of "compass" sense).

Elasmobranchs also have scales and paired fins, though some may be reduced or absent in some species.

There are over 200 species of skates found in all waters worldwide. They are dorsoventrally flattened with a fleshy tail that lacks spines or a stinger. Skates are

predators and some species are endangered as result of overfishing.

Examine the ***skate*** and find the ***mouth, gill slits, spiracles, pectoral fins, dorsal fins, tail (caudal) fins, pelvic fins, claspers (if you have a male), and electrosensory organs.*** Pry open the mouth of the skate and note the ***plate like teeth for crushing clams***.

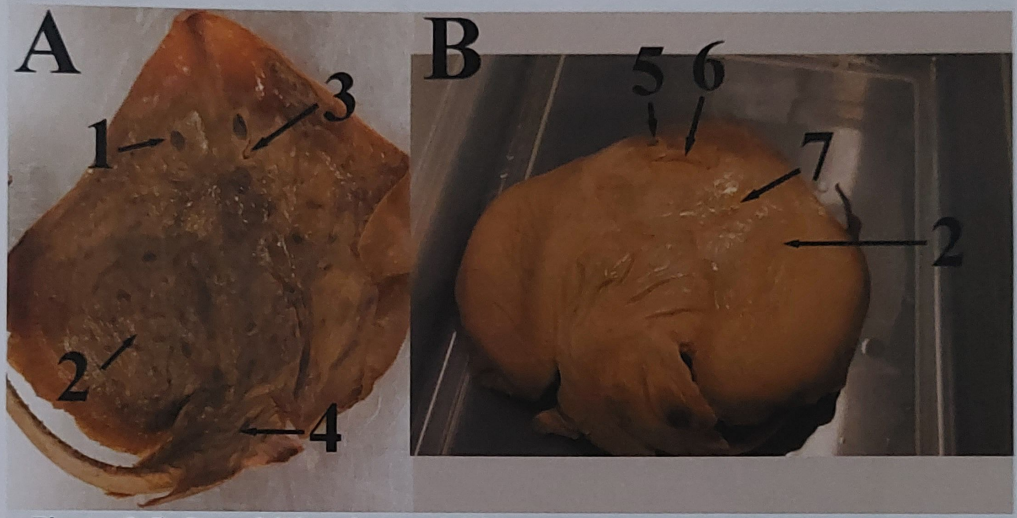

Figure 9-5. Dorsal (A) and ventral (B) images of a preserved skate. Key: 1=Eye; 2=Pectoral fins; 3=Spiracle; 4=Caudal fin; 5=Nares (nostril); 6=Mouth; 7=Gill slits.

There are over 300 species of rays including stingrays, electric rays, sawfish, and eagle rays. These predators differ from skates in several ways (see textbook).

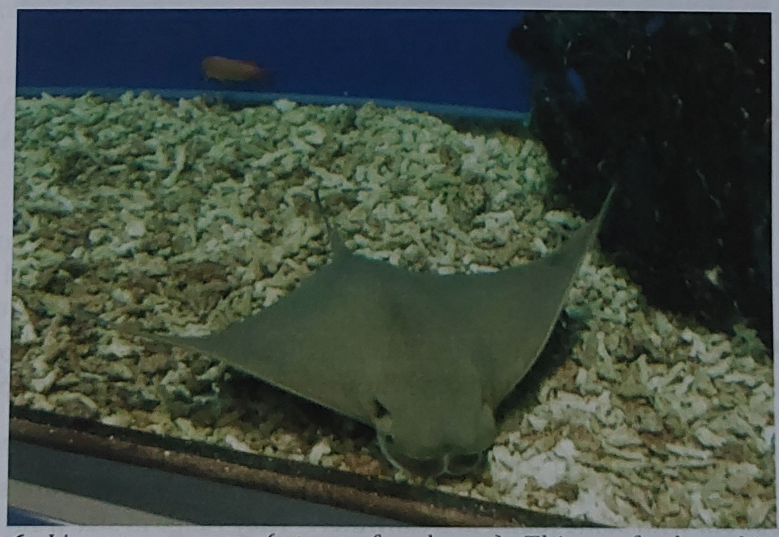

Figure 9-6. Live cownose ray (a type of eagle ray). This ray feeds on bivalves and other invertebrates.

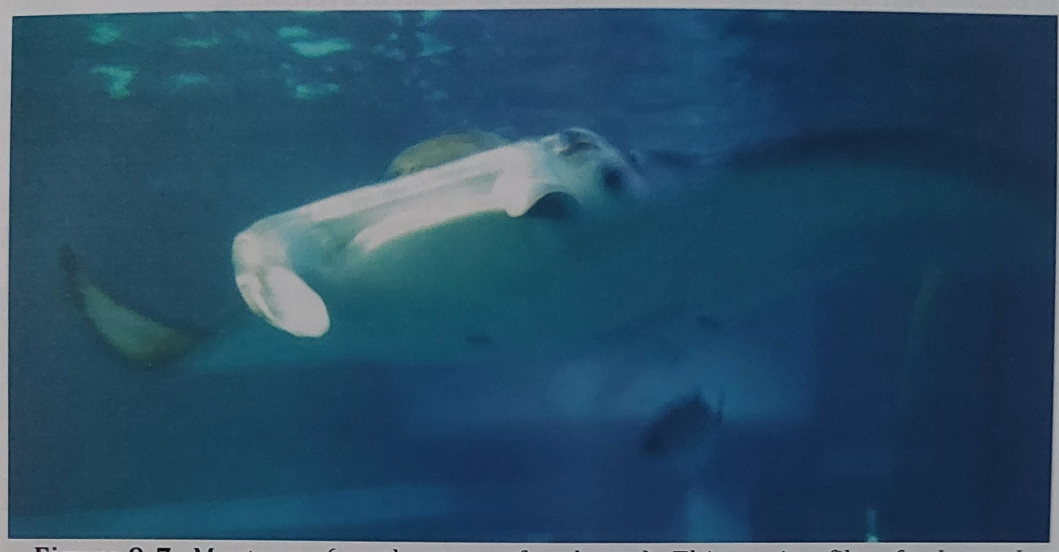

Figure 9-7. Manta ray (another type of eagle ray). This ray is a filter feeder and uses the cephalic lobes to direct food to its mouth.

Figure 9-8. Southern stingray in the Bahamas. This ray feeds on invertebrates buried in the soft substrate. The bony fish swimming just above it is a species of jack.

There are over 400 species of ***sharks*** found worldwide in all waters down to depths of 2000m with some found in freshwater. They range in size from 17cm (dwarf lanternshark) to the largest fish in the world, the whale shark, at 12m. Their

diet is just as diverse as their distribution with some being planktivores while others feed on invertebrates and fishes as well as mammals and birds.

Like skates and rays, they have multiple rows of teeth that are replaced frequently over the course of their lives. They have five, six, or seven gill slits on each side of their heads.

Figure 9-9. Whale shark. These sharks are the largest fish and feed on planktonic prey.

Examine the shark "skull" and jaws.

Examine the preserved specimen of a shark and perform a dissection.

Shark external anatomy: find the ***nostril, eye, mouth, spiracle, gill slits, pectoral fins, pelvic fins, claspers (if present), dorsal fins, caudal fin, organs of Lorenzini*** (i.e. electrosensory system; these are the small pits in the skin near the mouth).

Internal anatomy (do this with 2 lab partners)

1) Make a mid-ventral incision through the ventral body wall, including the mouth.

2) Find the following***: gill filament, gill raker, heart, gonads, stomach, intestine, liver, kidney, rectal gland***.

3) In order to get credit of attending today's lab, you must show the instructor your dissection.

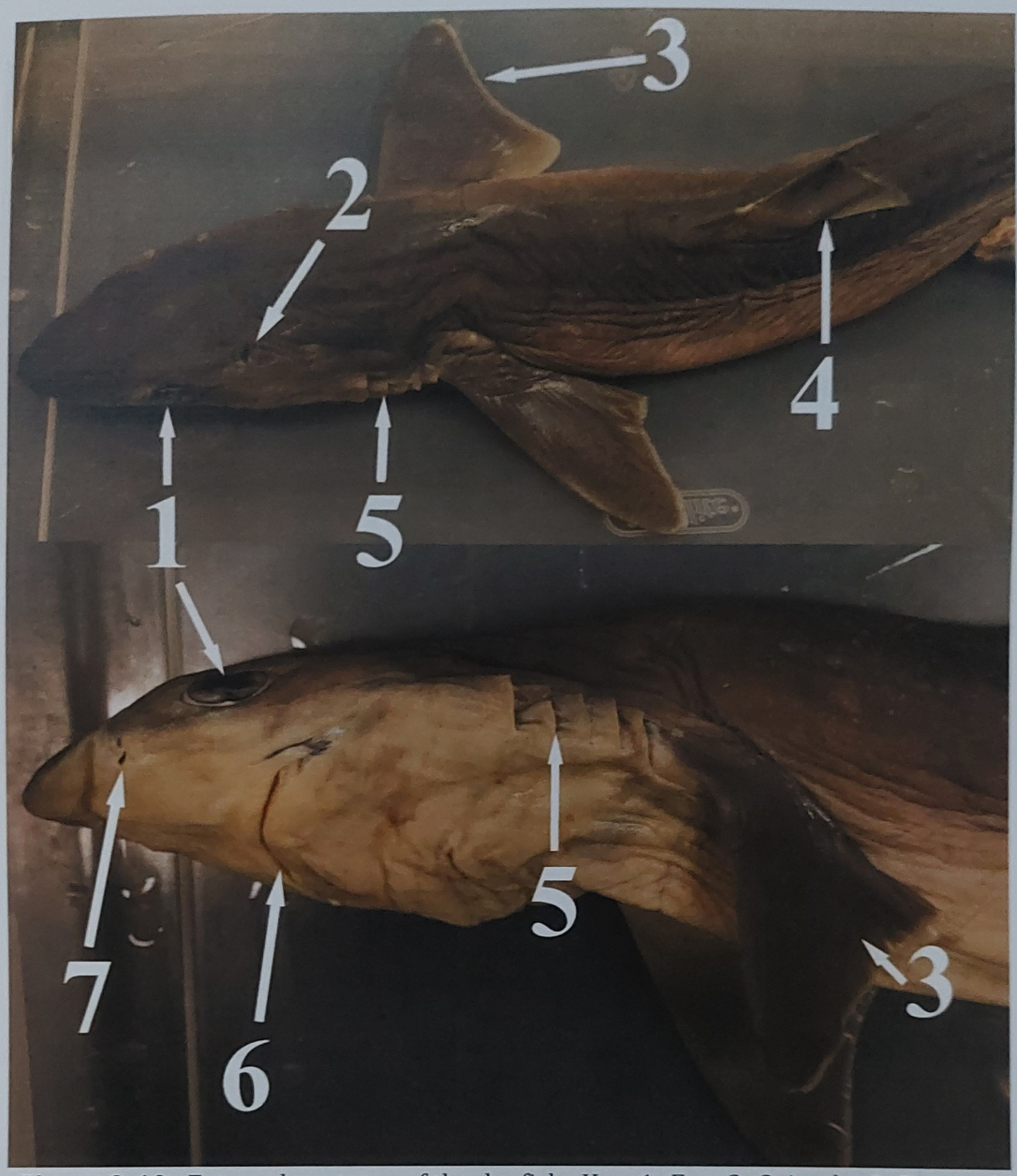

Figure 9-10. External anatomy of the dogfish. Key: 1=Eye; 2=Spiracle; 3=Pectoral fins; 4=Dorsal fin; 5=Gill slits; 6=Mouth; 7=Nares (nostril).

Questions

1. What were the similarities of the larvae of the organisms you examined today? What were the differences?

2. Compare and contrast the external anatomy of the hagfish and the lamprey?

3. How were the sea squirts and colonial tunicates similar? How were they different?

4. What does the morphology of the ratfish tell you about its ecology?

5. What were some of the anatomical similarities you saw between skates and dogfish? What were some differences?

6. Are skates, rays, and sharks broadcast spawners? Why or why not?

7. What does the location of the lateral line and electrosensory systems of the ratfish, skates, and dogfish tell you about their ecology?

Laboratory 10: Chordates 2

Bony fish comprise about 24,000 species spread throughout the marine and freshwater ecosystems. They are found in all marine waters worldwide from tropical coral reefs, the deep water, the pelagic zone, and even Polar regions. They have jaws, a bony skeleton and bony operculum covering the gills, and many have a swim bladder for buoyancy. They have various body forms and means to avoid predation. Bony fish also exhibit multiple feeding types including herbivores, carnivores, scavengers, and filter feeders.

Like the fish we saw last week, bony fish have a lateral line sensory system (in addition to their other senses) that helps aid in predator avoidance, prey capture, and schooling or shoaling behavior.

Atlantic Mackerel (*Scomber scombrus*) are fast swimming pelagic fish in the same group as tunas and swordfish. They are found on both sides of the North Atlantic Ocean. They are adapted for high-speed continuous swimming by ram ventilating their gills and will drown if they stop swimming; in addition they lack a swim bladder. These fish are common along the coast of Maine during the summer; they swim in schools and eat small herrings (anchovies), various fish larvae, and planktonic crustaceans.

Part 1. Mackerel

Work in groups of three for the dissection of the Atlantic Mackerel.

A. External Anatomy

Find the following: ***mouth, operculum, dorsal fins, pectoral fins, pelvic fins, anal fins, caudal fin, operculum***. Also note the following: ***coloration (counter shading, small scales, streamlined shape)***.

B. Internal Anatomy

Make a mid-ventral incision along the ventral surface of the fish. Cut skin and muscle away from the body cavity so you can observe the internal anatomy. Find the ***gill rakers, gill filament, heart, kidney, gonads, stomach, intestine, pyloric caeca, fin support (rays).*** See Figure 10-15, page 237 in the textbook.

The ***mullet*** is typical of ***many slow swimming fish. Note the large scales in comparison to the mackerel, and the less streamlined shape***. This fish also has a ***swim bladder.*** Mullet are bottom feeders that suck up mud and strain out food with their gill rakers. Mullet typically swim in schools south of us along the Atlantic Coast.

Examine the fresh (if present) and preserved specimens of the mullet. Find the ***mouth, operculum, dorsal fins, pectoral fins, pelvic fins, anal fins, caudal fin,***

operculum and compare these with the other fish you find in lab.

Examine the preserved specimen of the striped bass: this fish is basically like the mullet as far as its body plan. Find the items listed above.

Croaker and grouper: these fish are basically like the mullet as far as their body plans. Find the items listed above.

Figure 10-1. Grouper in the Bahamas.

Part 2. ***Reef fish***

A. ***Seahorse***. There are approximately 54 species of seahorses in shallow temperate and tropical waters around the world. They live in seagrass beds, mangroves, coral reefs, and estuaries. They lack a caudal fin and are poor swimmers, so are found near the bottom attached to substrate features via their tail.

Examine the preserved seahorse. Find the ***operculum, dorsal fin***.

B. ***Puffer fish***.

Puffer fish are found inshore and in estuarine waters in temperate and tropical waters. They are ***slow swimming*** reef fish that ***inflate their bodies with water to increase their size*** and also have spines on their bodies for protection. This fish belongs to a family that has the most recently derived feeding mechanism in bony fishes. They are also among the most venomous vertebrates in the world.

Figure 10-2. Puffer fish.

Examine the preserved puffer fish.

See Atlas for additional fishes found on coral reefs.

C. Epipelagic fish.

Cutlassfish is a large fish found on the continental shelf in tropical waters. It is long and slender predator that remains 50 to 100m below the surface during the day and ascends to the surface at night to hunt.

Examine the preserved cutlassfish. Note the following adaptations: ***laterally compressed body, large eyes, silver sides (at least when the fish was fresh), large teeth, swim bladder***.

D. ***Bottom fish.***

Conger Eels can grow up to 3m in length. They are found from near shore out to the edge of the continental shelf. It lives in "tunnels" and between rocks. It feeds primarily on fish e.g. flounder and herring, but also on shrimp and clams. Note the ***fin placement*** and the presence of a ***swim bladder***.

Examine the preserved specimens of other bottom dwelling fish: the sculpin,

rock eel, goosefish, and flounder. Find the following: ***eyes, mouth, operculum, pectoral, pelvic, anal, dorsal and caudal fin. Be able to identify these fish as bottom dwellers***.

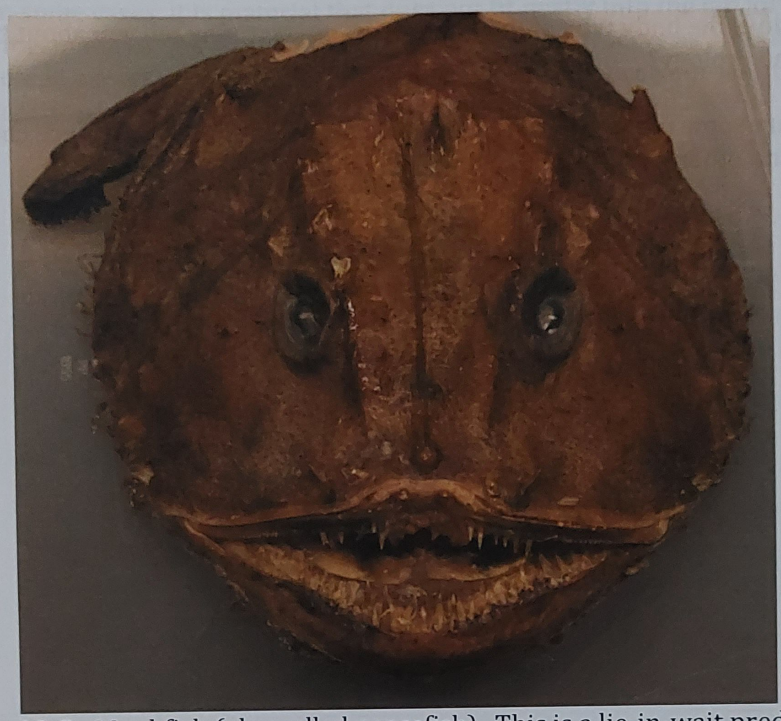

Figure 10-3. Monkfish (also called goosefish). This is a lie-in-wait predator on other fishes. Note the lure attached to the face just above the mouth.

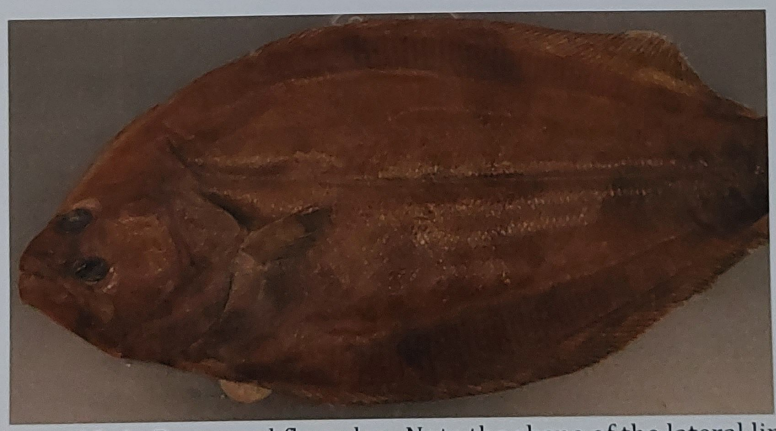

Figure 10-4. Preserved flounder. Note the shape of the lateral line.

Questions

1. What does the morphology of each fish you examined today tell you about their feeding strategy?

2. What does the body type of the fish you examined today tell you about their habitat and ecology?

3. What are some of the adaptations of these fish that help them reduce competition for food and other resources?

Atlas

The purpose of this atlas is to provide supplementary material for the manual. In some cases, it is material that does not fit neatly into the lab for the day. In others, it is material you would not otherwise cover or to serve as an example of what you could expect to see in live cultures. It is all to enhance your learning experience in the lab.

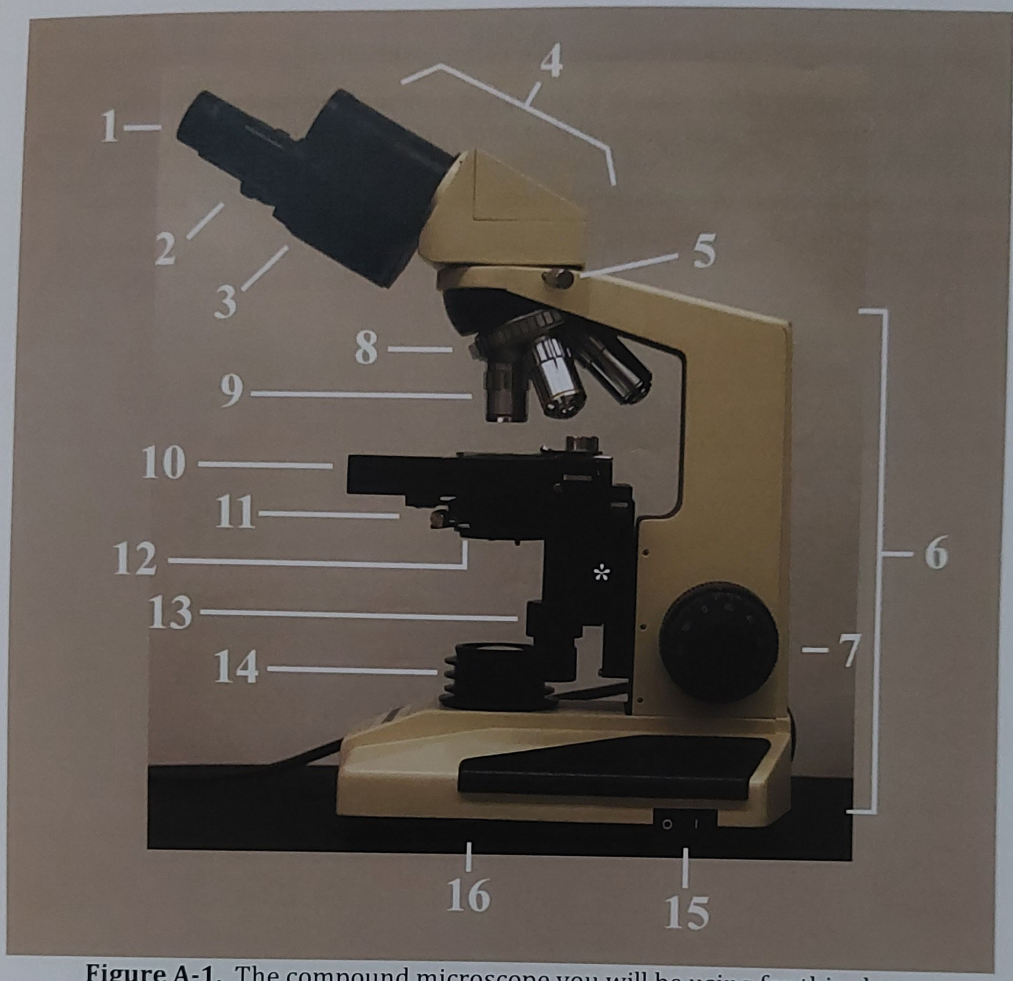

Figure A-1. The compound microscope you will be using for this class.

Key to the Compound Microscope

1 Ocular lenses (or eyepieces)
2 Ocular tube and diopter adjustment ring
3 Interpupillary adjustment
4 Head assembly
5 Head set screw
6 Stand
7 Coarse and fine focus control knobs
8 Objective turret (or nosepiece)
9 Objective lens
10 Stage
11 Condenser assembly (contains condenser, condenser centering screws, iris diaphragm adjustment lever)
12 Blue filter in swing-in filter holder
13 Mechanical stage X-Y axis adjustment knobs
14 Light source
15 Power switch
16 Brightness control wheel
* Substage condenser assembly adjustment knob

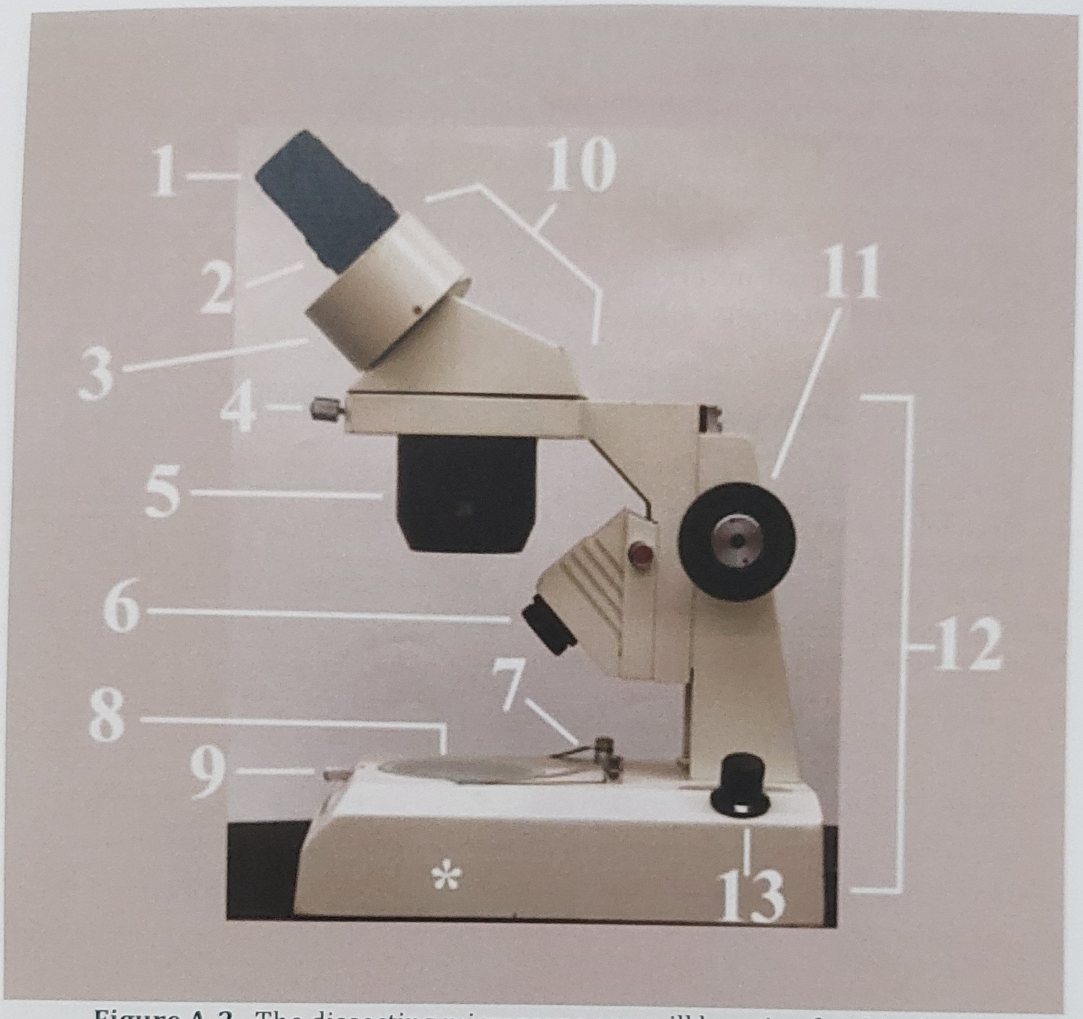

Figure A-2. The dissecting microscope you will be using for this class.

Key to the Dissecting Microscope

1 Ocular lenses (or eyepieces)
2 Diopter adjustment ring
3 Interpupillary adjustment
4 Head set screw
5 Objective lens turret (lenses inside the turret)
6 Incident light
7 Stage clips
8 Watchglass
9 Watchglass set screw
10 Head assembly
11 Focus control knob
12 Stand
13 Power switch
* Brightness control wheel

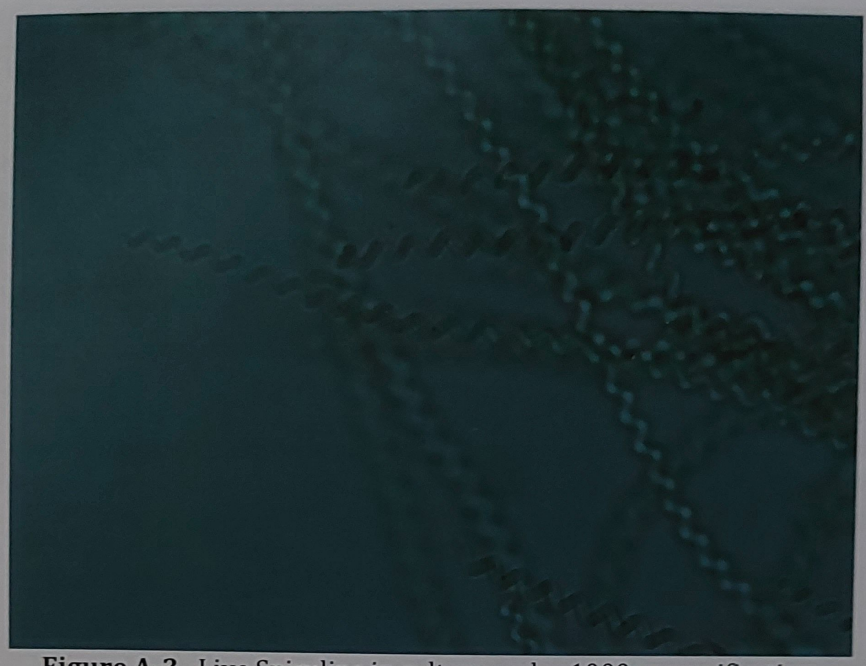

Figure A-3. Live Spirulina in culture under 1000x magnification.

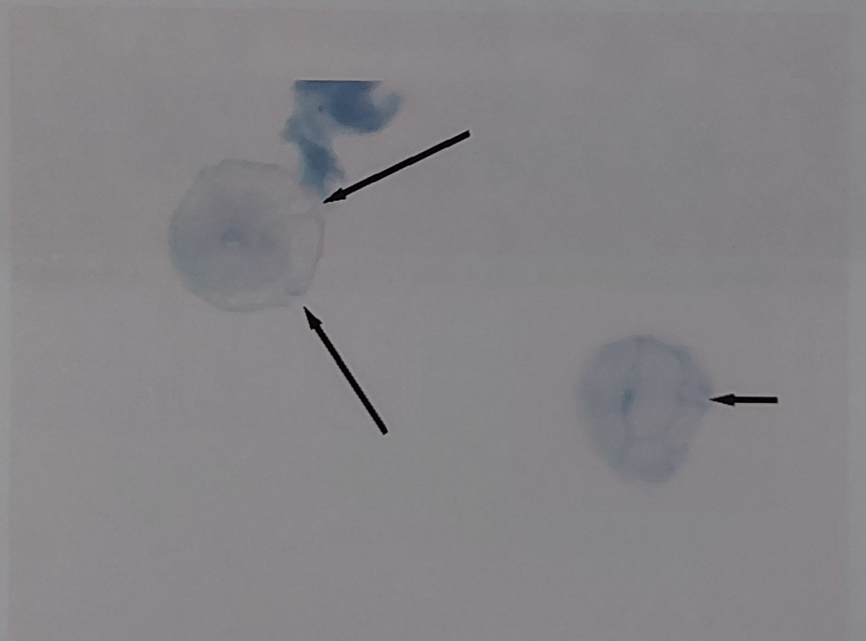

Figure A-4. Microscope images of two dinoflagellates taken under 200x magnification. The arrows indicate the grooves where the flagella would attach.

Figure A-5. Unicellular organisms found in pond water at 200x magnification. When you make a wet mount and get the general focus, look for movement.

Figure A-6. Green fleece, a type of green algae, found on East Coast of the U.S. from Maine to about New Jersey.

Figure A-7. Sea colandar, a type of brown algae.

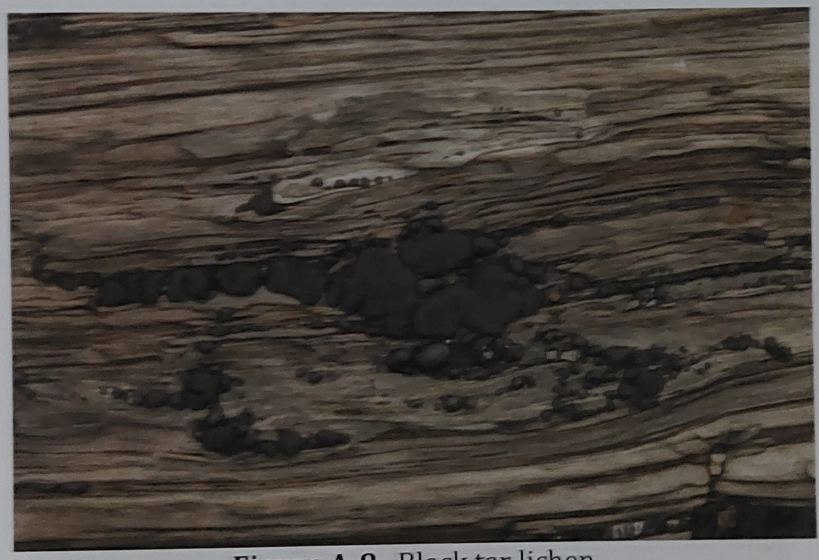

Figure A-8. Black tar lichen.

Figure A-9. Salt marsh ecosystems are subject to tidal flow and freshwater inputs from rain, terrestrial runoff, and streams. This is the salt water stream that cuts through Spurwink Marsh in Cape Elizabeth, Maine. Note the 'island' above. Periodically, the banks of the canal become detached so there is a constant shifting of the route of water flow through the marsh.

Figure A-10. Pans found at the Spurwink Marsh. Even slight elevation changes can cause one pan to be bare while others will be filled with water.

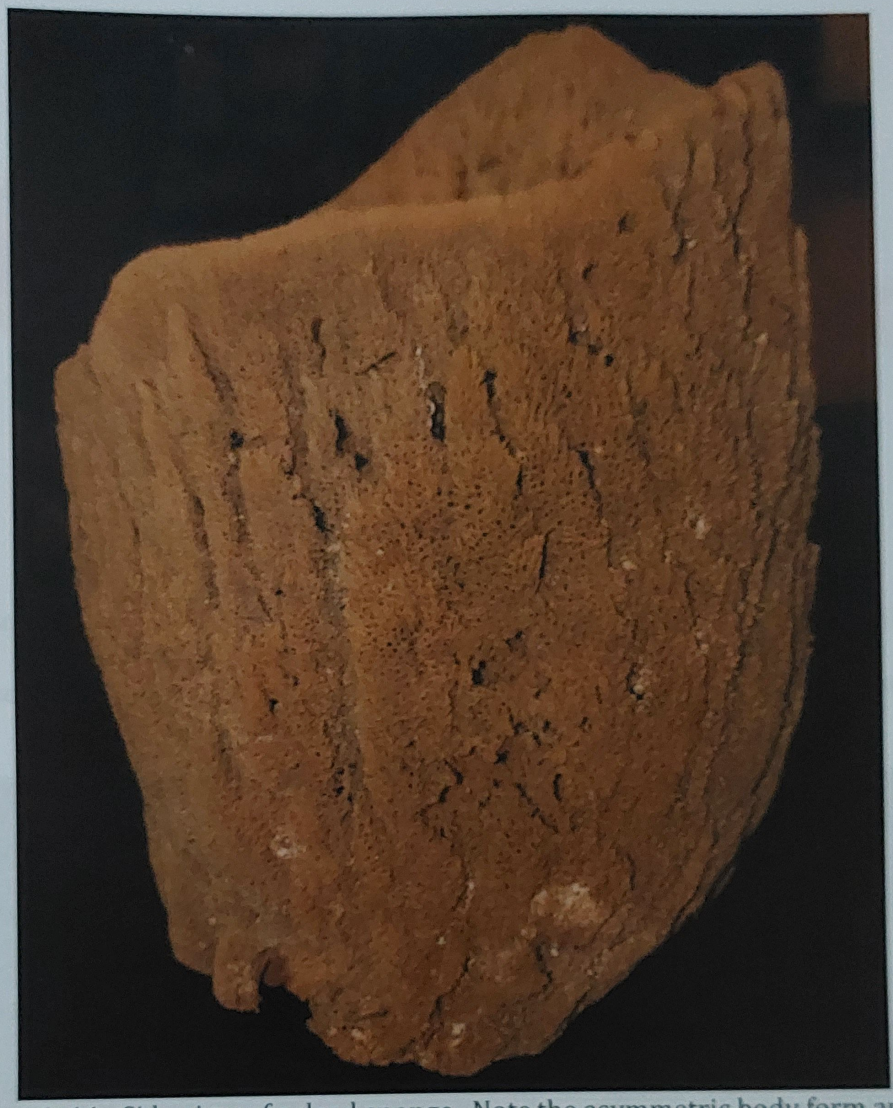

Figure A-11. Side view of a dead sponge. Note the asymmetric body form and the pores in the body. Water flows in through these pores and out through the osculum at the top.

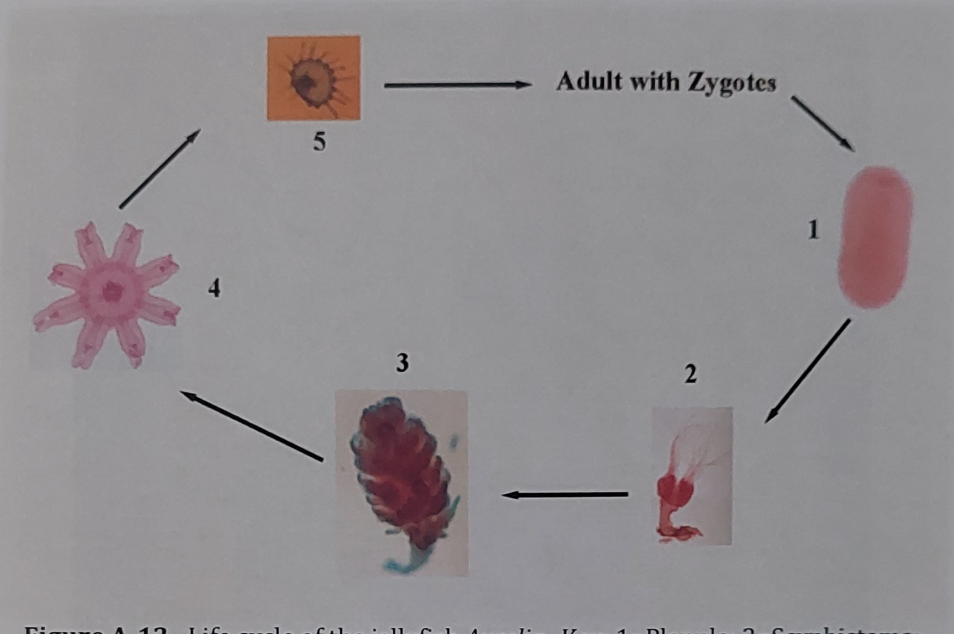

Figure A-12. Life cycle of the jellyfish *Aurelia*. Key: 1=Planula; 2=Scyphistoma; 3=Strobila; 4= Ephyra; 5=Medusa.

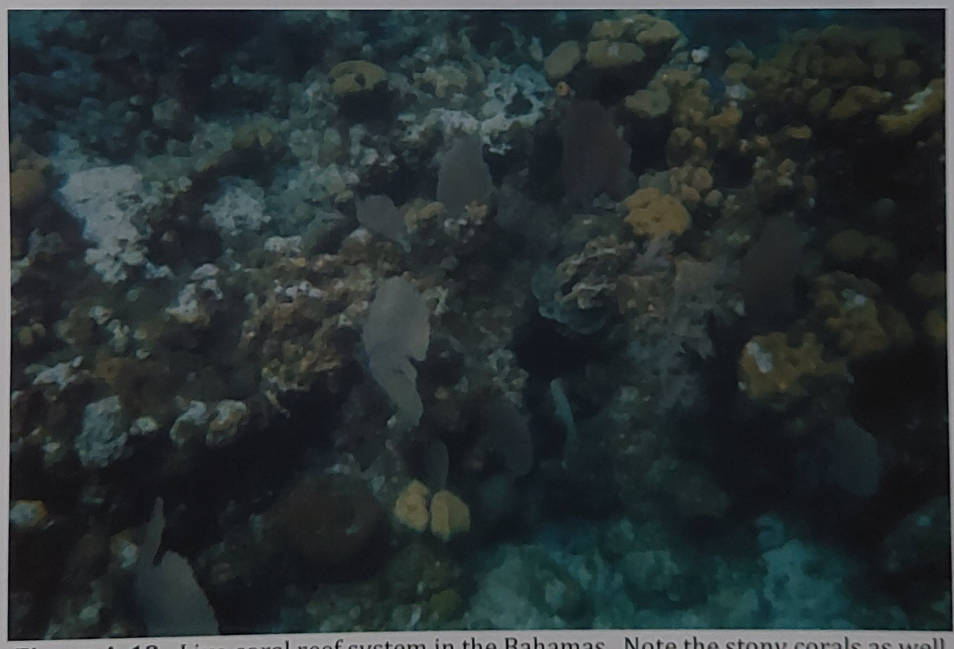

Figure A-13. Live coral reef system in the Bahamas. Note the stony corals as well as the soft corals.

Figure A-14. Elkhorn coral in the Bahamas. This is an important reef-building coral that has shown a tremendous depletion in numbers since the 1980s.

Figure A-15. Sea pens are soft corals with polyps that have specialized functions.

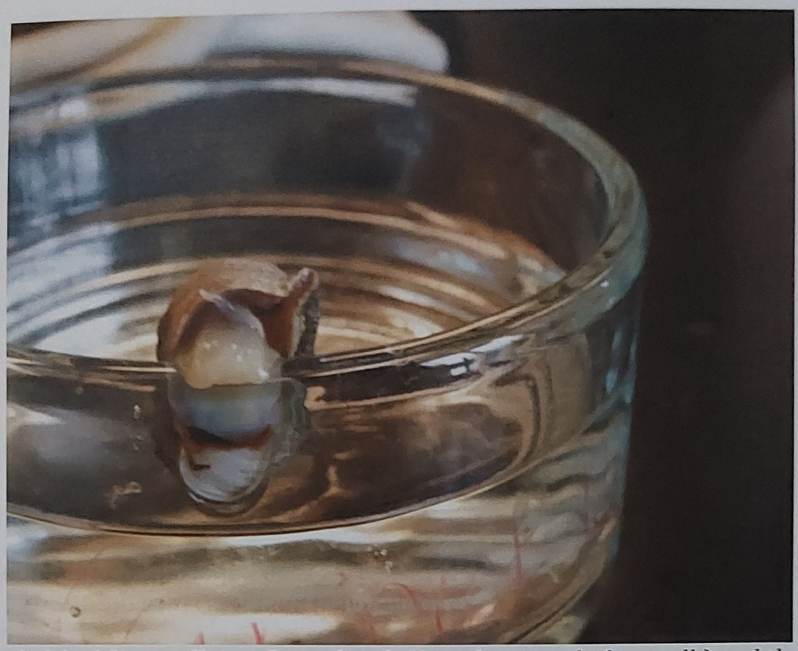

Figure A-16. A live welk in a finger bowl. Note the tentacle (eyestalk) and the siphonal notch that identifies this as a predatory gastropod.

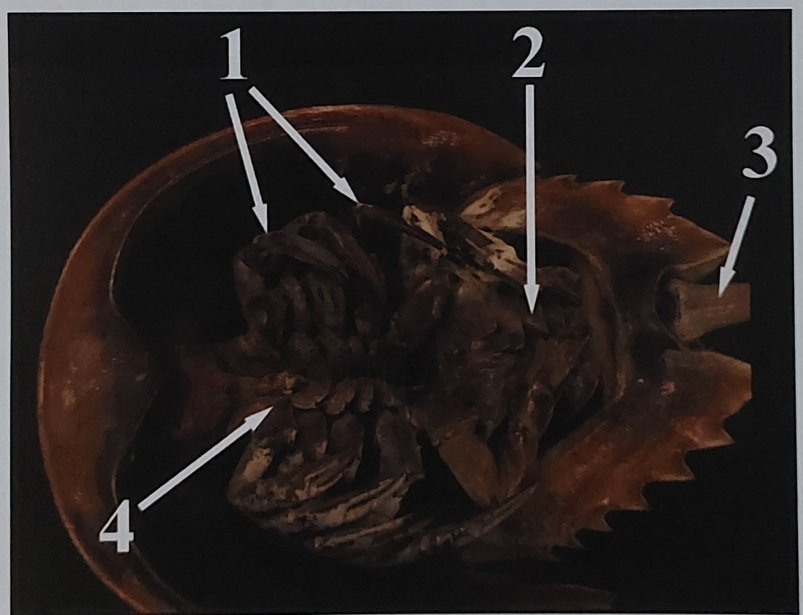

Figure A-17. Ventral view of an adult female horseshoe crab. Key: 1=Legs; 2=Abdomen; 3=Telson; 4=Cephalothorax

Figure A-18. Microscope image of a barnacle nauplius under 50x magnification.

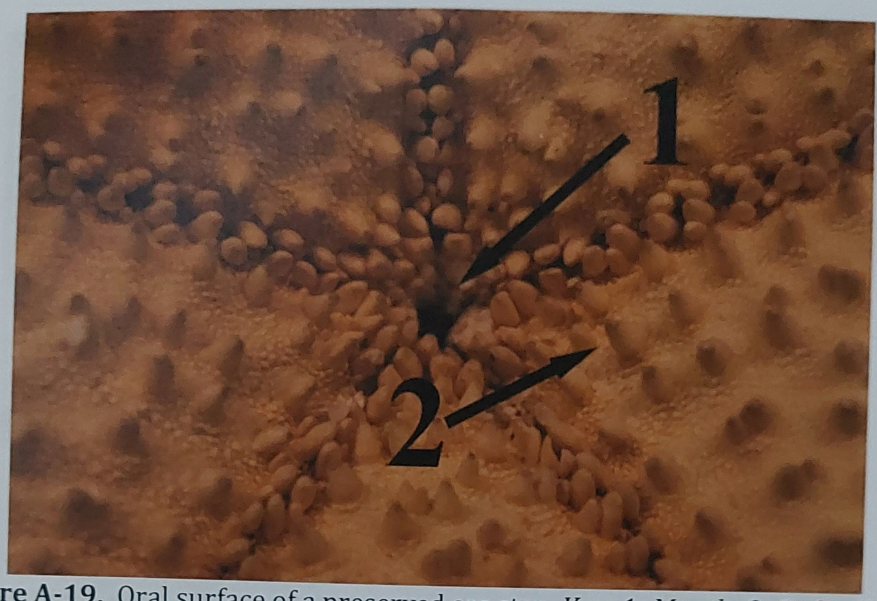

Figure A-19. Oral surface of a preserved sea star. Key: 1=Mouth; 2=Pedicellaria.

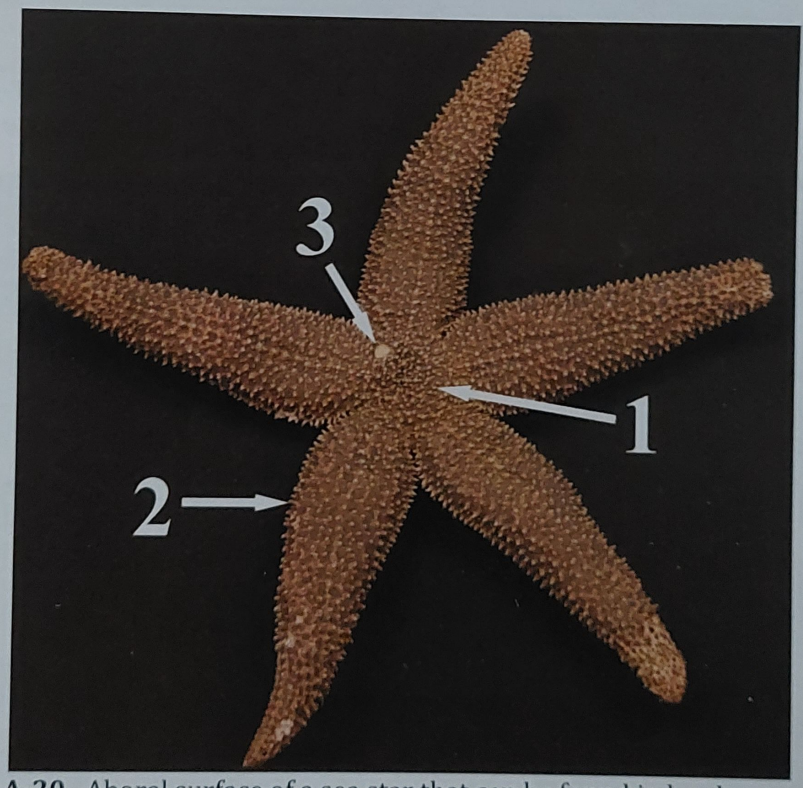

Figure A-20. Aboral surface of a sea star that can be found in local waters. Key: 1=Central disc; 2=Arm; 3=Madreporite.

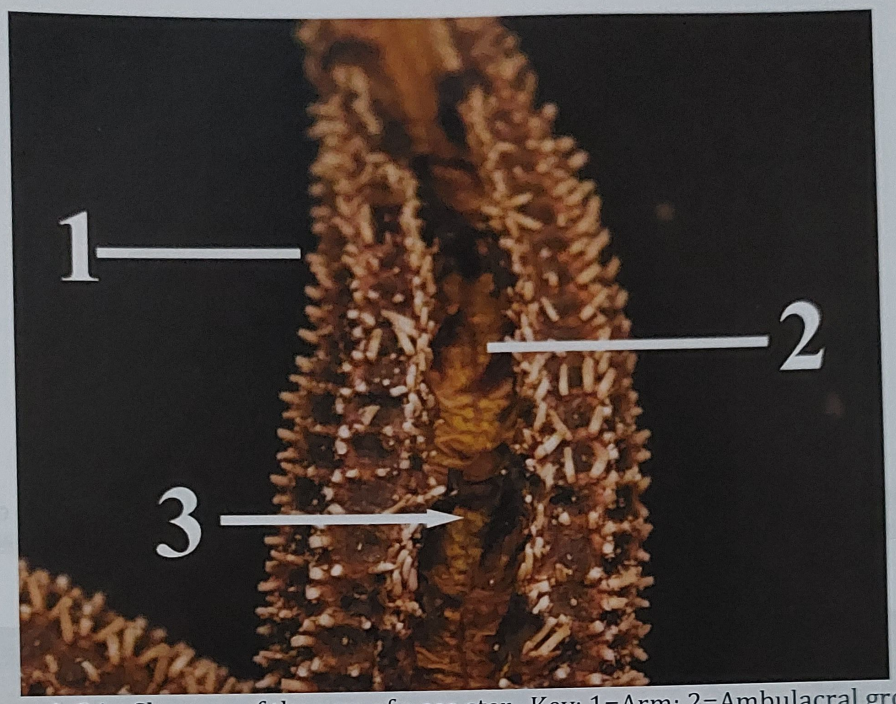

Figure A-21. Close up of the arm of a sea star. Key: 1=Arm; 2=Ambulacral groove; 3=Radial canal for the water vascular system.

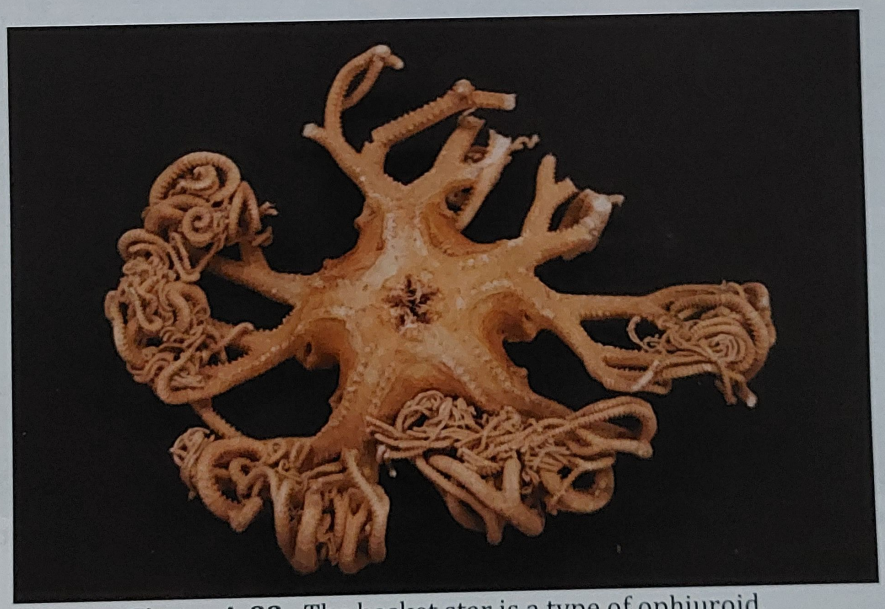

Figure A-22. The basket star is a type of ophiuroid.

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